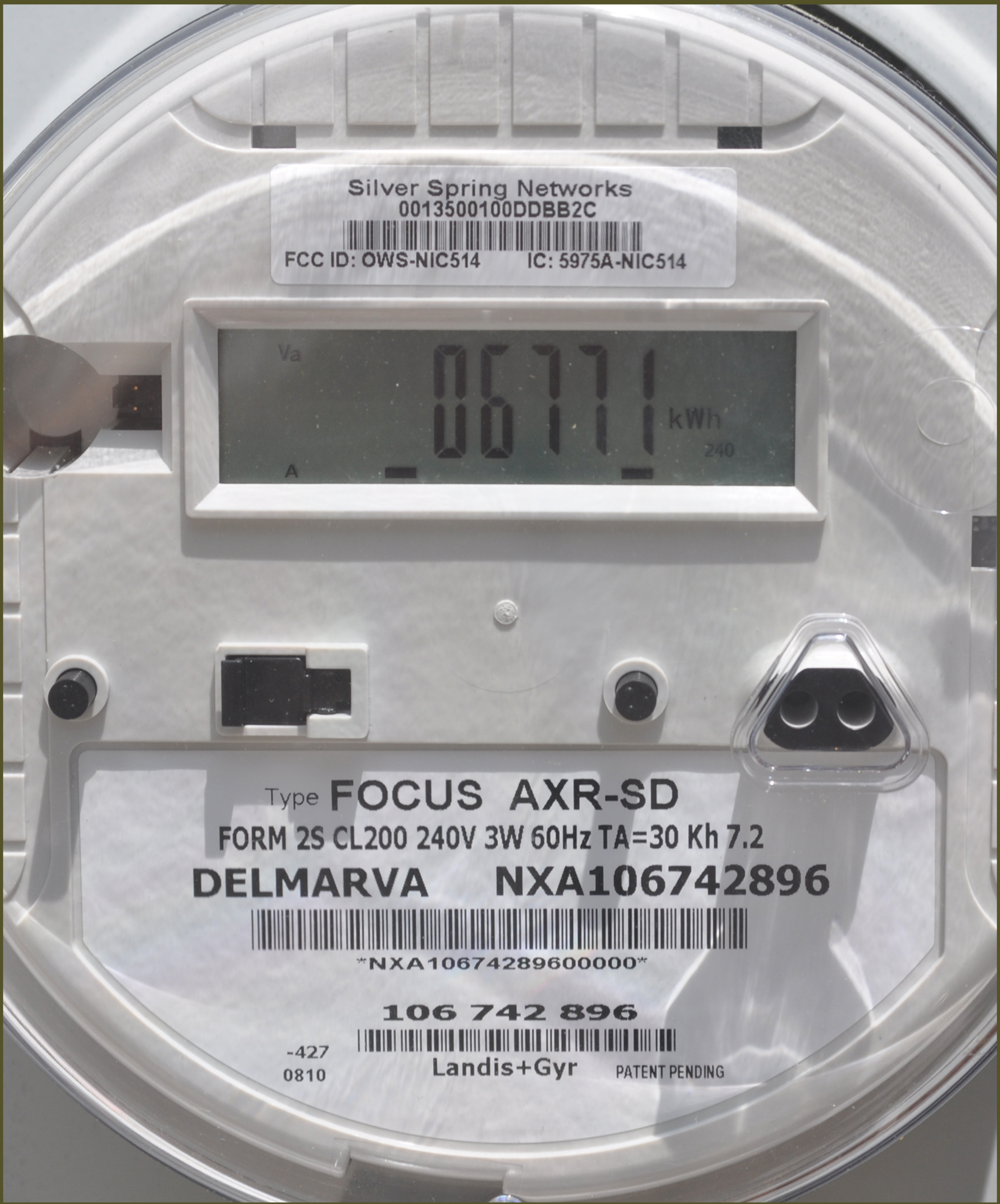
Energy, the Environment, and Delaware Jobs:

Households and Energy Efficiency

Daniel T. Brown
Edward C. Ratledge



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by

Daniel T. Brown
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This is the fourth in a series of reports titled “Energy, the Environment, and Delaware Jobs”. The entire series is comprised of the following five titles:

Energy Efficiency and the Manufacturing Sector

Defining and Describing Green Businesses

An Analysis of Delaware’s Green Educational Pipeline

Households and Energy Efficiency

The Economic Impact of Delaware’s Green Business

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Executive Summary

Overview

The four year old housing bust and ensuing financial crash has left the economy in general, and the construction sector in particular, facing a great deal of hardship and uncertainty. Unemployment is at 30 year historical highs, employment has stagnated, and growth rates are well below those consistent with a typical recovery. In addition, businesses complain that the workforce is not skilled enough to perform those jobs that are available. The recent focus on developing the labor force for jobs today and in the future is both appropriate and urgent.

The political leadership of Delaware, the nation, and much of the developed world have pinned their hopes on the development of the green economy and its potential job growth. If these visions are to be turned into viable actions, they must face the critical questions and confront the economic tradeoffs imposed by reality. Policy makers need more than a sophisticated description and tabulation of green jobs. They also need to know how many jobs can be expected, what type of training is needed, and whether those jobs will be sustainable. They also should understand the relationship between green jobs and non-green jobs. Answers to these questions depend on many factors, only some of which can be addressed in a single report.

This report looks at the behavior of households and the private demand for green products and services. Specifically, it focuses on the degree to which households are interested in and able to buy green products and services. In particular, we ask why are households interested in becoming energy efficient, how are they achieving this, and what are they willing to give up? Understanding consumer demand for green goods and services is essential to forecasting business demand for green jobs.

Research Design

Survey research was the methodology selected to understand Delaware consumers. In particular, the survey queried Delawareans living in owner occupied homes. Owner occupied households were targeted because unlike renters, owners are in direct control of the residential purchasing decisions that impact energy efficiency and pollution.

The research design provided for nearly equal samples to be drawn from each of the three counties in Delaware. The achieved sample sizes were 665 interviews in Kent County, 713 in New Castle County, and 661 in Sussex County, for a total of 2,039 observations in Delaware. These samples provided nearly equal precision (+/- 3.4% at the 95% confidence level) for the survey responses. The data was weighted to reflect the actual numbers of owner occupied housing units; 91,760 owner-occupied homes in Kent, 286,265 owner occupied homes in New Castle, and 122,158 owner occupied homes in Sussex. The final sample was also weighted for age and gender within each county.

After inferring many key implications from the survey results, we then apply demographic and econometric forecasting techniques to estimate the future private residential demand for energy-efficient construction services. Next, those future demand projections are converted into labor requirement so that a baseline measure of labor demand can be constructed. This enables any projection of green market share for certain products to have a meaningful interpretation of labor requirements.

Survey Findings

The findings from the survey are divided into six parts. Highlights from each one are discussed below.

Demographic and Energy Profile

The median income of respondents was $55,000, slightly above the median family income in the state. The average age was 50, but respondents in Sussex County were slightly older (55). Nearly 44% of respondents had a college degree, 83.9% were white, and 12.8% African American. Four percent were of Hispanic origin.

The average household living in an owner-occupied house has been living there for 14 years, and more than 75% of the respondents expect to be living in that house for at least two more years. The average age of an owner-occupied housing unit in Delaware is 32 years old. In Kent and Sussex counties, the average age of a home is 24 years and in New Castle County the average age of a housing unit is 37 years. Substantially larger percentages of owner-occupied housing units in Kent and Sussex were built in the last decade.

Over 80% of the housing is of the single-family variety with a noticeable difference between the counties. Kent and Sussex have proportionally more manufactured housing units than New Castle, while New Castle has substantially more duplexes and townhomes. New Castle also has a relatively larger proportion of housing units greater than or equal to 3,500 sq. ft.

Heat is provided by electricity (29.9%), natural gas (40.1%), fuel oil (18%), and propane (8.1%). Kent and New Castle counties have similar energy profiles, with the exception that New Castle uses less propane. In Sussex, electricity (38.8%) and propane (19.1%) are significantly more common energy sources that provide heat. This is expected, given that the distribution of natural gas by pipeline is much more developed in New Castle County than in Sussex. The average age of the heating system is almost 10 years, with 13% of heating systems being older than 20 years. The average age of water heaters is nearly seven years, and 20% of these are more than 10 years old.

The average monthly bill for electricity was $222.00, and the average gas bill was $208. Electric bills were substantially different across the counties, with New Castle homeowners having the largest bills. On the other hand, homeowners in Sussex have substantially larger gas bills, primarily because propane tends to be more expensive.

Perceptions and Behavior

Approximately 37% of homeowners claimed to use less energy than their neighbors, while only 10% thought they used more. Nearly 84% reported that they were already trying to reduce energy use, and 61% claimed to be taking additional steps to reduce pollution. Almost 70% asserted that reducing energy use was definitely a worthwhile goal. 75% of respondents indicated that they recycled.

As for their actual performance, 53% reported making home improvements in the last two years that was intended to reduce energy use. Of those projects mentioned, windows and doors were the most common (20.3%), followed by laying insulation (13.1%), making changes to the heating system (10.3), and sealing cracks or making repairs and alterations to the exterior (8.6%). Approximately 8.1% stated that they purchased a new appliance in the last two years in order to save energy, and over 74% of the homeowners interviewed suggest that they buy ENERGY STAR appliances when replacing old appliances.

One of the easiest ways of saving energy use is to install and use a programmable thermostat. The survey shows that 60% of the respondents have this device; but only 71% of those with the device actually set it. Taken together, 43% of owner occupied households have a fully operational programmable thermostat. There is clearly an opportunity to lower energy consumption at little to not financial cost.

Financial Considerations

Almost 70% of the respondents indicated that monetary savings, both in the first-year and in the succeeding-years, were the two most influential reasons behind making an energy saving investment. The other choices e.g., environment, reduce oil imports, and having a green reputation trailed. When asked what would discourage them the most from making an energy saving investment, 30% of homeowners identified the upfront costs, 23% identified the risk of financial savings not being achieved, and 15% indicated the risk of improper installation.

Respondents were also given a hypothetical scenario in which an energy saving investment was told to lower energy costs by $600 per year for five years for a total of $3000. The majority responded they would pay less than $1200 for that stream of benefits, implying that they would be willing to wait a little more than two years. Implicitly then, homeowners stated that they expected a minimum rate of return on the project of 50% (APR).

In another scenario posed later, homeowners responded that they were willing to wait little less than three and a half years to recoup the costs of an investment that had 10 years of benefits. Under certain assumptions, the implicit return that the average household demanded has an APR of nearly 28%. This suggests that even when households view investments from the perspective of time to recoup investment (instead of money required upfront), the average homeowner still demands extremely high returns on energy-saving investments. These high demands may reflect the real or perceived financial risk of investing in energy efficiency.

Only 34% of respondents indicated that they would be likely to replace a working appliance with a more energy efficient appliance. Similarly, less than 20% were willing to replace a water heater until it breaks. When asked about considering the installation of solar panels, 18.7% were either *very* or *definitely likely* to do so. In fact, approximately the same proportion of respondents expressed interest across all income groups, implying that many homeowners have not seriously considered the cost of that technology.

Energy Audits

Residential energy audits indentify wasteful energy consumption in the home, so homeowners can know which projects are most beneficial. However, the audits only diagnose inefficiencies and recommend changes; they do not actually fix anything. Thus, paying for these audits is a difficult proposition to homeowners, since they do not know what, if anything, will be found. Moreover, homeowners do not know what the cost will be to fix those deficiencies, or if they are paying someone hundreds of dollars to make an elaborate sales pitch. Reputation plays a major role, but so do incentives between energy auditors and construction companies (or lack thereof).

About 22% of respondents indicated that they were very or definitely interested in an energy audit. In a follow-up question, the price of an audit ($200-$600) was disclosed, and more than 60% of those that expressed interest were no longer interested. However, when they were told of a rebate of 20% of the audit's cost, 45% of those who had lost interest became interested again.

This led to several questions on what homeowners would do if repairs were needed. If the problem was insufficient insulation, more than 50% said that they would likely do the repair themselves. If the problem was leaky air ducts, 40% said that they would do the repair themselves. If the problem centered on cracked and drafty windows, 30% said they would do the project themselves. Hiring of professionals to correct these problems adds to the out-of-pocket cost and reduces the net expected value of an energy audit.

Hybrid/Electric Vehicles

Almost 60% of the respondents indicated that the fuel mileage will be a factor in purchasing their next vehicle. This is consistent with the response obtained when asking about the attractiveness of hybrid vehicles. About 44% of respondents said that they thought a hybrid engine made the vehicle more attractive. When asked about the attractiveness of 100% electric powered vehicles, a smaller group, 26%, responded positively.

If all-electric vehicles were priced competitively with other vehicles, 34% of homeowners said that would view all-electric vehicles favorably. Respondents from Kent and Sussex counties tended to look upon electric vehicles less favorably than homeowners living in New Castle County. This may be caused by lower housing densities, commuting patterns, and travel patterns. Income differences seemed not to matter.

Employee Perspectives

The survey also asked employed respondents to describe any work activities or experiences that were relevant to energy efficiency and pollution reduction. When asked if reducing energy use was important to their employer, 55% responded affirmatively that it was either *very important* or *definitely important*. More than half (51.4%) felt that it was relatively easy to suggest ways of improving energy use and/or reduce pollution.

A little more than 70% of respondents said their companies had programs to reduce energy use or prevent pollution in the work place, and 19% of these respondents said that those programs required some kind of job training. When asked to describe that training, the most common answer was general awareness or occupation-specific training (3.4% of those employed), followed by going paperless and recycling (3% of those employed).

When asked if they had ideas about other ways that their companies could save energy or reduce pollution, 27.7% responded affirmatively, of which 20% thought that those ideas would require job training. Most of those ideas centered on recycling, going paperless, working from home, and turning off lights, equipment, and computers when not in use.

This material in this section suggests that most of those processes that businesses do to reduce energy and lower pollution requires behavioral changes from their employees. This likely implies that occupational training may be less important to reducing energy use than the ability to supervise employees.

Application of Consumer Demand

The second section of this report uses the results from the survey along with supplementary data from the 2009American Housing Survey and reports from the Joint Center for Housing Studies at Harvard University to predict the annual future demand for six types of home improvement projects critical to the efficient use of energy. Specifically, the projects include insulation, water heaters, air conditioning systems, heating systems, windows and doors, and roofs. We estimate that approximately $300 million would normally be spent by existing Delaware homeowners each year. Nearly 60% of that expenditure is expected to be spent on roofs, windows, and doors. Replacing water heaters is projected to be the second most common project (21,000 water heater repairs /replacements in Delaware each year), but due to the low cost of these projects, only $15 million of homeowner expenditure will be made each year.

Translating these expenditures into employee requirements, we expect that 1,629 employees will be needed to do these six project types each year. 510 workers will be needed for roof repairs, 388 for windows and doors, 286 for heating systems, 307 for air conditioning systems, 82 for water heaters, and 55 to lay insulation. To put that in perspective, these direct jobs translate to 7.6% of the construction sector, and 0.4% of covered employment.

Of course, not every roofing project or every air conditioning repair will be considered green, but that largely depends on what definition one uses to label a job as 'green'. In addition, homeowners that have lower energy costs will likely divert some of those additional resources to be spent on other goods and services, so other jobs will likely be created in other ways. We explore these issues in other reports in this series.

Introduction

Much discussion surrounds the prospect of green jobs, which are currently recognized as being between two to four percent of jobs today depending on the definition and measurement. Will these jobs use today's federal and state support to flourish and grow into a sustainable private market? If such a shift occurs, what does that imply about households, businesses, educational institutions, and individual workers? The answers to these questions are anything but clear, but they clearly depend on whether households and businesses consume environmental and energy-efficient products and services. Those private consumption decisions are very important to understanding which green jobs will be sustained in the future and are the focus of this report.

The Center for Applied Demography & Survey Research (the Center) has undertaken an analytical review of Delaware's green economy. As part of this review, we are releasing a series of reports that analyze different facets of the green economy. This report is intended to address how Delaware households will impact the green economy, primarily as consumers. We accomplish this objective using a survey of Delaware homeowners. In that survey, we collect information pertinent to the consumption of energy efficient goods and services. Later, we combine that information with forecasting methods in order to project annual consumer demand for the next ten years. Finally, we convert that demand into probable job requirements.

The target population of the survey is decision-makers within owner-occupied housing units in Delaware. Renter-occupied units were excluded since renters typically do not make decisions concerning energy-efficient green goods and services in the residential sector.

In addition to projecting future labor demand for certain types of green jobs, the survey also embarks upon original data collection to better understand the households' opinions regarding green goods and services, such as ENERGY STAR appliances, energy audits, and electric vehicles. Questions in the survey address behavioral, perceptual, and financial considerations facing green consumers.

The survey also asks questions concerning the households' perspective of environmental concerns at their place of work. Specifically, employed Delaware homeowners were asked if and how their employer responds to environmental issues. While homeowners do not reflect all employees, they do represent a significant portion of the labor supply. Moreover, relatively little empirical research has been done concerning green work activities in the workplace, despite the prominent role that these activities play in the definition of green jobs.

To summarize, the information collected in our survey falls into six main areas:

1) Basic demographics and energy profile of the household;
2) Opinions regarding energy efficiency and pollution reducing behavior;
3) Financial considerations related to energy efficiency;
4) Opinions regarding energy audits and household behavior;
5) Attitudes concerning hybrid and electric vehicles;
6) Experience with green job training at their place of employment.

This report is structured into two main sections following this brief introduction. The first section reviews the survey results for each of the six components listed above. The second part of the report applies forecasting methods to the survey data in order to estimate the future demand for home improvement projects critical to energy. That demand is then used to derive future employment needs.

Section I – Survey Results

Housing and Respondent Demographics

One of the main goals of this study is to understand the beliefs and opinions of decision-makers living in owner-occupied households in Delaware. For both statistical and policy reasons, this population is further delineated by the state's three counties: Kent, New Castle, and Sussex. Since each county has a very different profile with respect to income, labor market, and population, it is important to consider any differences when prescribing policy.

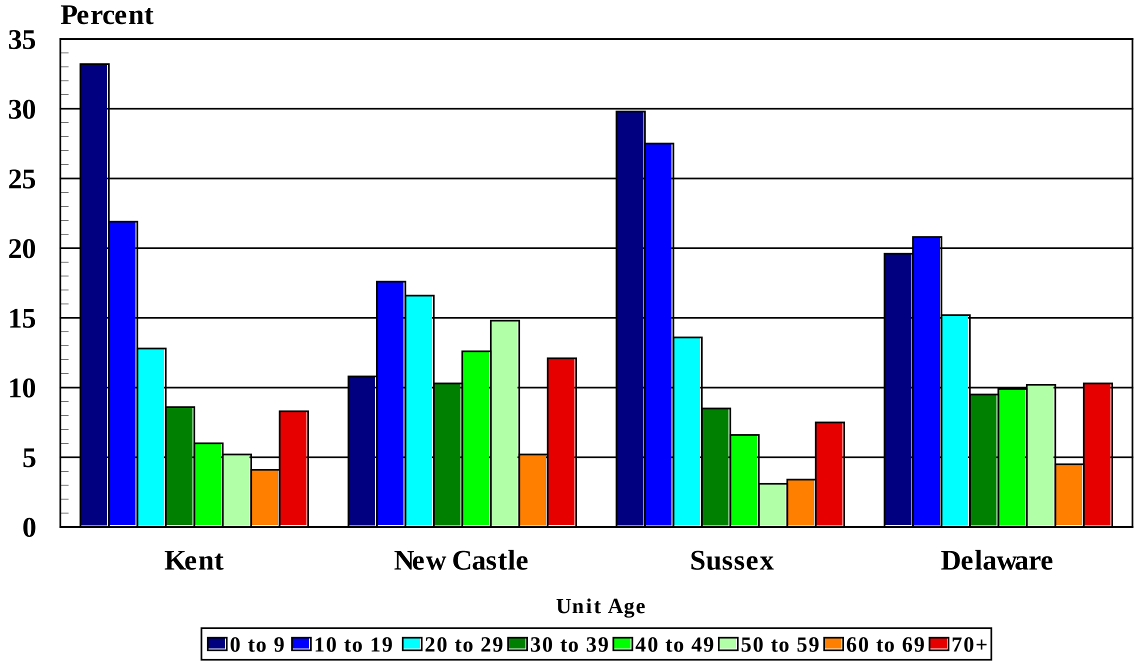
The research design drew approximately equal samples from each county so that the results have nearly equal precision (+/- 3.4% at the 95% confidence level). The survey collected 665 responses from Kent County, 713 responses from New Castle County, 661 responses from Sussex County, for a total of 2,039 interviews.[1] The data was weighted to reflect the actual numbers of owner occupied housing units, as well as age and gender within each county.

The median income of the respondents was $55,000, slightly above the median family income in the state. The average respondent age was 50, but the average respondent in Sussex County was slightly older (54.8 years old). Approximately 44% of the sample had a college degree. 83.9% of respondents were white, 12.8% were African American, and four percent were of Hispanic origin.

The remainder of this section profiles the housing stock and energy patterns in each county.

[1] There are 91,760 owner occupied households in Kent County, 286,265 owner occupied households in New Castle County, and 122,158 owner occupied households in Sussex County.

Figure 1 - 1 Age of Owner Occupied Housing, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

Housing Characteristics

The distribution of the age of owner-occupied housing for each county and the state is shown in Figure 1 - 1. A larger share of recently built housing is in Kent and Sussex counties than it is in New Castle County. The growth in Kent County is correlated with both the housing bubble which began in 2003 and the opening of DE Route 1. The pattern in Sussex County is primarily a function of the continuing migration of retired persons. As more retired persons migrate to the county, the construction and service sectors of the economy are stimulated.[2]

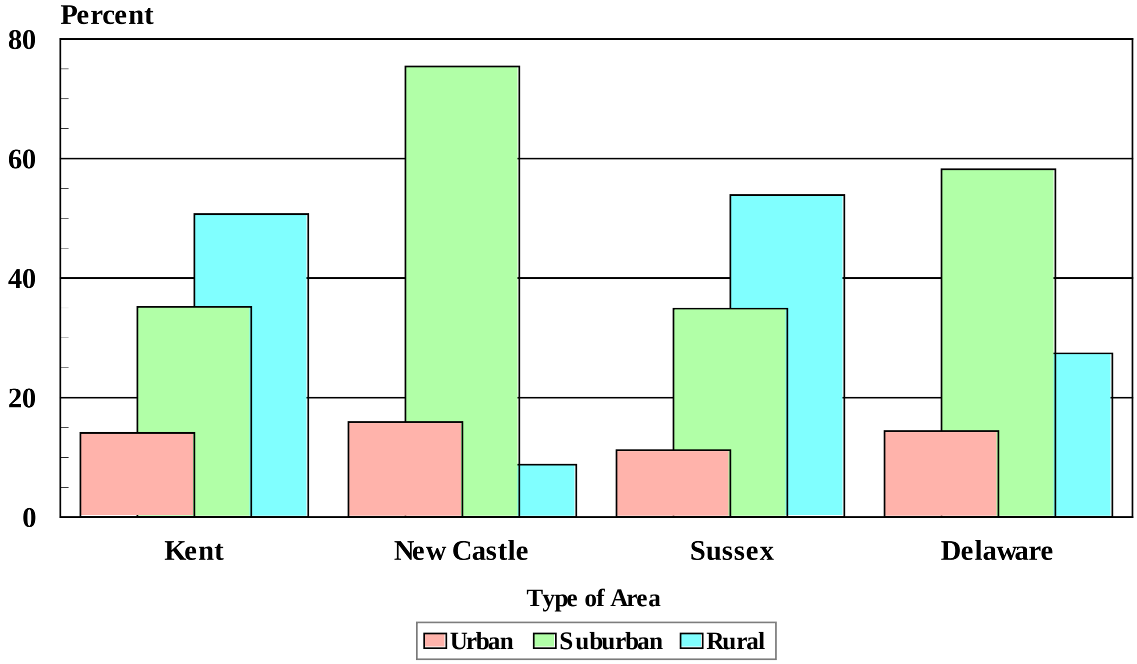
[2] A table of means, standard errors, and margins of error is available online at www.cadsr.udel.edu.

The average age of owner occupied housing is 25.6 years in Kent County and 23.8 years in Sussex County. The housing stock in New Castle is much older, averaging 37 years of age.[3] Multiple factors explain this age differential. First, New Castle County developed much faster in the later part the 20th century than the other two counties. In addition, new construction in New Castle has been hampered by the lack of net in-migration. The price of land and the location of available land also played a significant role in the county's slowdown over the past decade.

The distribution of owner occupied housing units in the state shows the definite increase in construction over the last three decades. The average age of those housing units is 31.7 years. Housing age is very important to energy efficiency for two primary reasons. First, energy use was less important in the design of buildings constructed during low historical periods of cheap energy. Therefore, retrofitting these homes' design may greatly reduce the home's energy consumption. Secondly, older homes are more likely to have residential capital and equipment at the end of their useful lives. Because energy consumption increases as equipment depreciates (e.g. holes in the roofing, drafty windows, old heating equipment, etc.), there are greater opportunities for improving energy efficiency.

[3] New Castle County's housing stock is significantly different from the other two counties ($ME_{.95}$ =2.46 years)

Figure 1 - 2 Housing Unit Density, by County

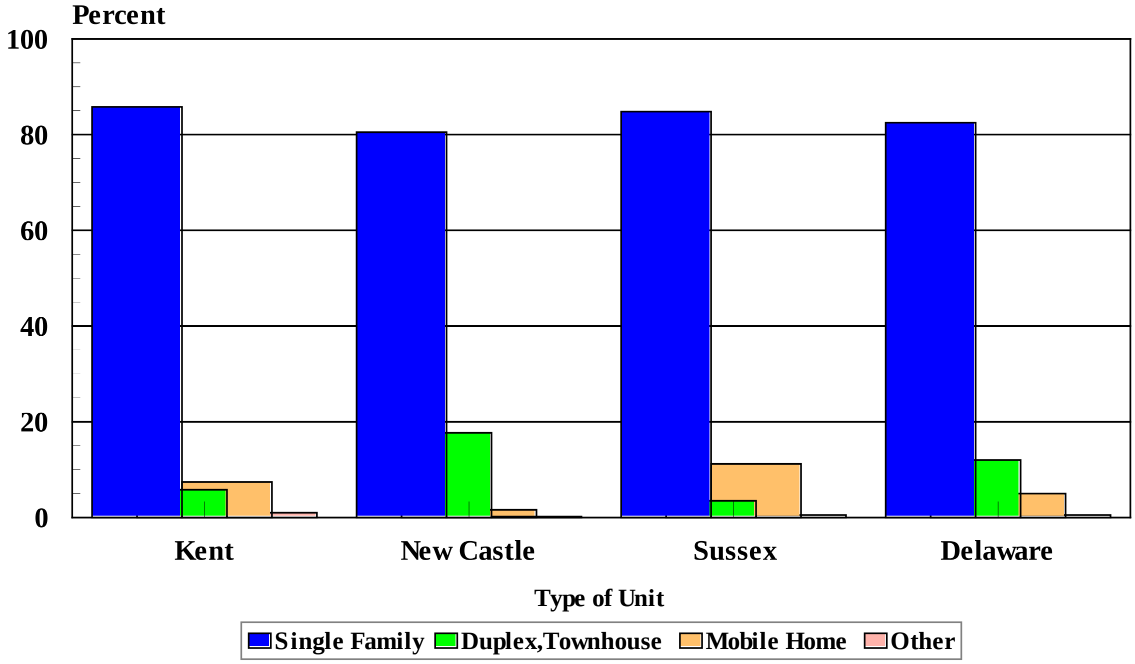


Source: Center for Applied Demography & Survey Research, University of Delaware

The location of owner-occupied housing may also have an impact on energy efficiency and pollution reduction. For example, urban locations are less likely to use geothermal heating or worry about well-water contamination. Density within an area also affects the type of energy being used (e.g. natural gas delivered by pipeline as opposed to propane held in tanks). Density is also important to the fiscal and environmental consequences of curbside recycling programs.

Figure 1 - 2 shows that Delaware is primarily a suburban state, with under 20% of owner occupied homes in the urban setting and approximately 30% in a rural setting. Although each county has approximately the same share of urban home-owners, significant differences exist between suburban and rural classifications ($ME_{.95}$ =4.11%). New Castle County has transformed most of its farm land into suburban developments, while Kent and Sussex remain primarily rural.

Figure 1 - 3 Housing Unit Type, by County



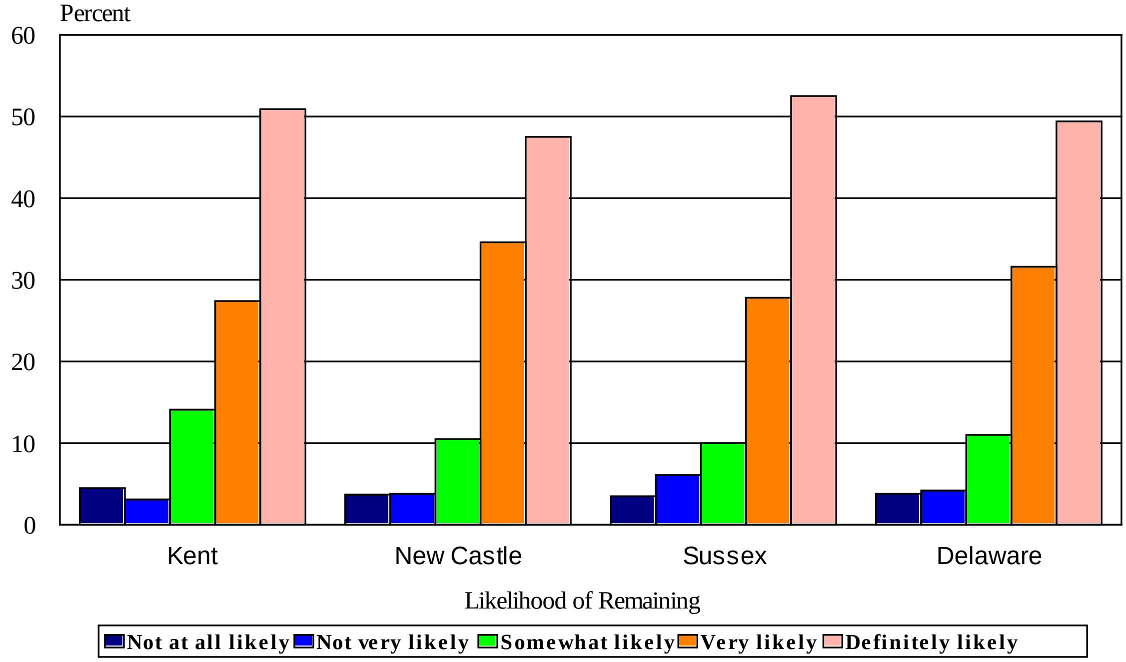
Source: Center for Applied Demography & Survey Research, University of Delaware

Figure 1 - 3 indicates that manufactured housing (i.e. mobile homes) has a significantly higher presence in Kent and Sussex counties, but is less than 2% of owner occupied homes in New Castle County ($ME_{.95}$ =3.3%). Lower income homes are commonly townhomes in New Castle County, but manufactured homes in Sussex and Kent. Also, many blocks of mobile homes in Sussex County act as "beach" homes prior to retirement.

Because heating and cooling a home use a large portion of the houshold's energy, the area to be heated and cooled within a home is a core component of energy efficiency. Moreover, area largely depends on the type of housing. The typical single family detached unit has 2,284 square feet of living space in Delaware. In comparison, the single family attached (duplex, townhouse) has 1,697 square feet, and the mobile home 861 square feet of space.[4] Energy use will be closely related to these differences.

[4] These differences are statistically significant ($ME_{.95}$ =173.1 sq. ft.)

Figure 1 - 4 Living in Current Residence in Two Years, by County

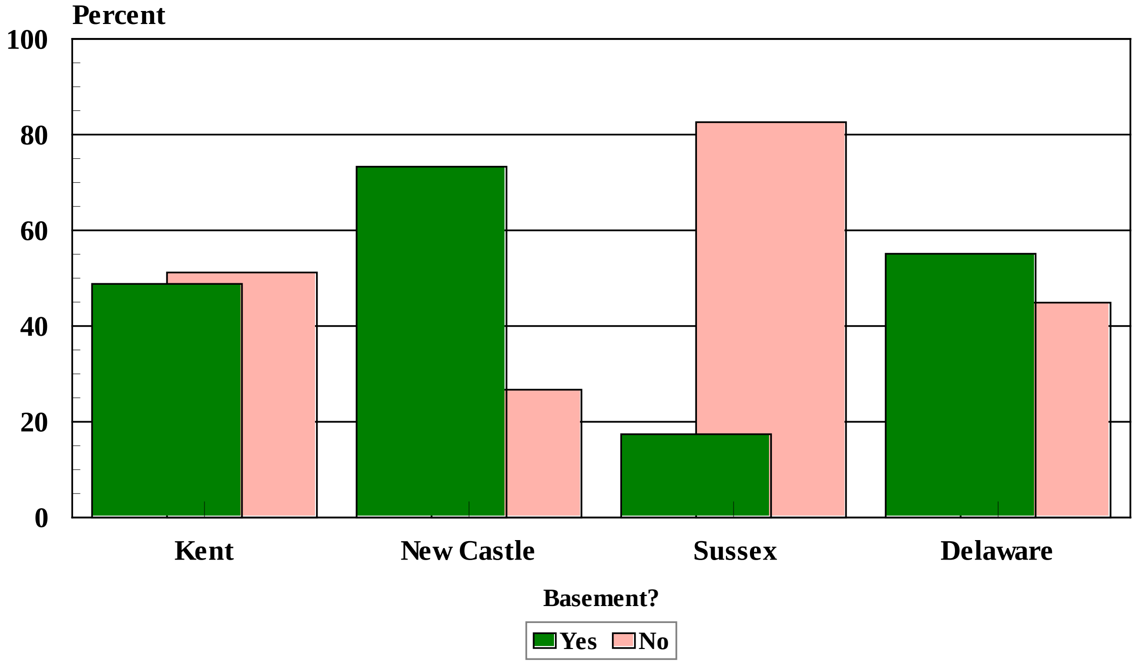


Source: Center for Applied Demography & Survey Research, University of Delaware

The willingness to invest in energy efficiency also depends on how long the homeowners intend to occupy the residence. If homeowners do not expect to stay in their home, there will be very little financial incentive to make long-term investments. Instead, homeowners expecting to move may choose remodeling projects that will most improve the sale price of the home, such as kitchen and bath remodeling. Of course, each house is different, so some energy-saving investments (e.g. windows and doors, roof, etc.) may be more likely to increase the expected price of the housing unit.

Figure 1 - 4 indicates that only about 10% of residents expected to leave their homes within the next two years, and about 80% were fairly certain that they would stay. There is very little perceived or statistical difference between the counties. This implies that at least 80% of the population could be a target for energy efficient investments that take a while to pay off.

Figure 1 - 5 Basement in Housing Unit, by County

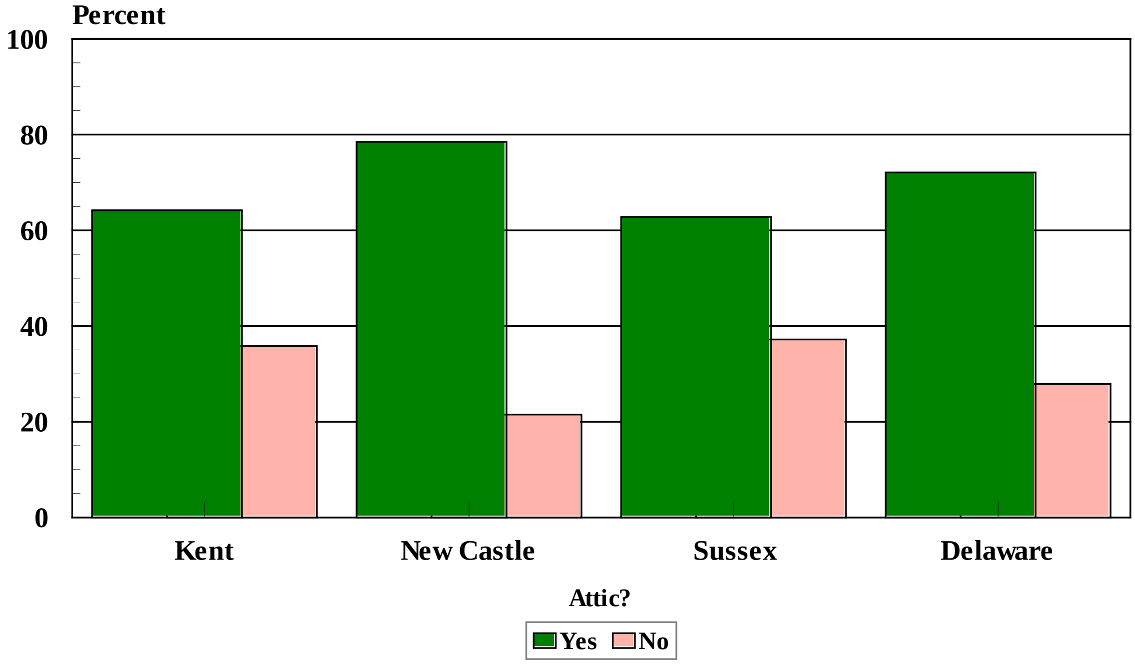


Source: Center for Applied Demography & Survey Research, University of Delaware

Units with basements, if properly insulated and conditioned, can be just as energy efficient as units which are built on a slab. The key is to achieve proper insulation and dry ventilation. Figure 1 - 5 contains the information about basements in owner occupied housing units. Sussex has significantly fewer units with basements than either Kent or New Castle ($ME_{.95}$ =4.57%). This is primarily because the water table in Sussex is very high and hostile to basements. In addition, many of the units in Sussex are intended to be vacation homes, and therefore in less need of a basement.

Given New Castle County's suburban development pattern, it is hardly surprising that 75% of owner-occupied units have basements. Kent County is evenly split in regards to whether the units have basements. Surprisingly, the percentage does not vary greatly by age of the house within county. The main take away is that projects involving basement insulation will likely have their biggest market in New Castle County.

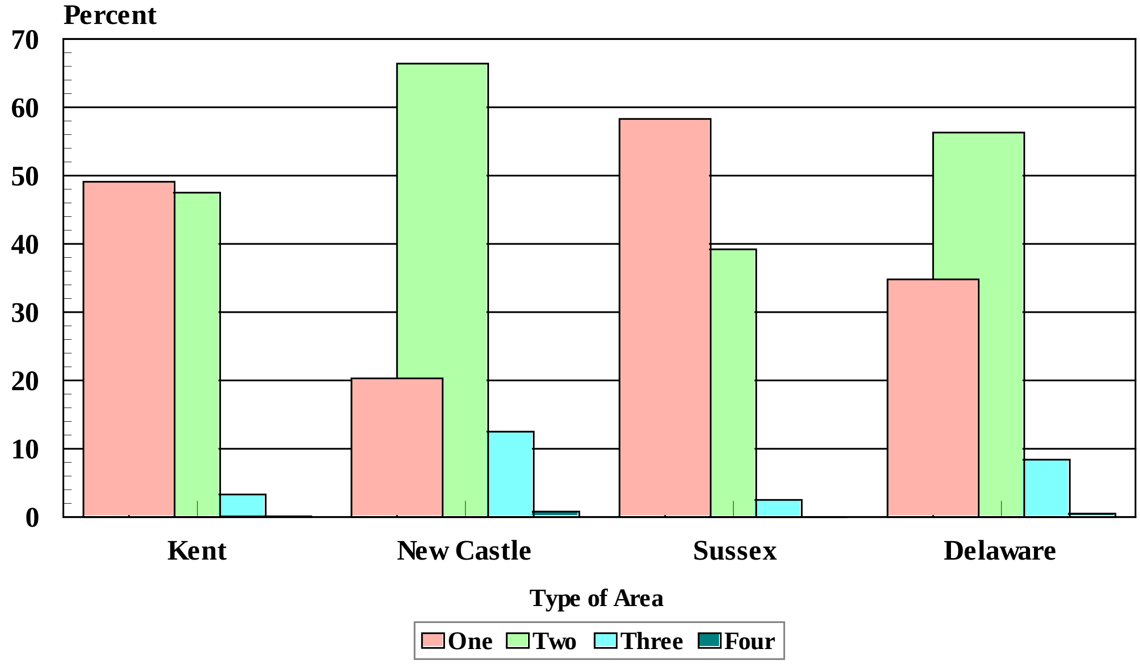
Figure 1 - 6 Attic in Housing Unit, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

Proper attic insulation is one of the first things homeowners think about when trying to lower energy costs. Figure 1 - 6 shows how many homes have an attic. Differences between counties are largely a function of housing type. Manufactured homes rarely have attics (2%), but 80% of single family detached units have them. In contrast, 60% of town houses and duplexes have attics, implying that all three counties likely have similar potential market opportunities for insulation.

Figure 1 - 7   Floors in Housing Unit, by County

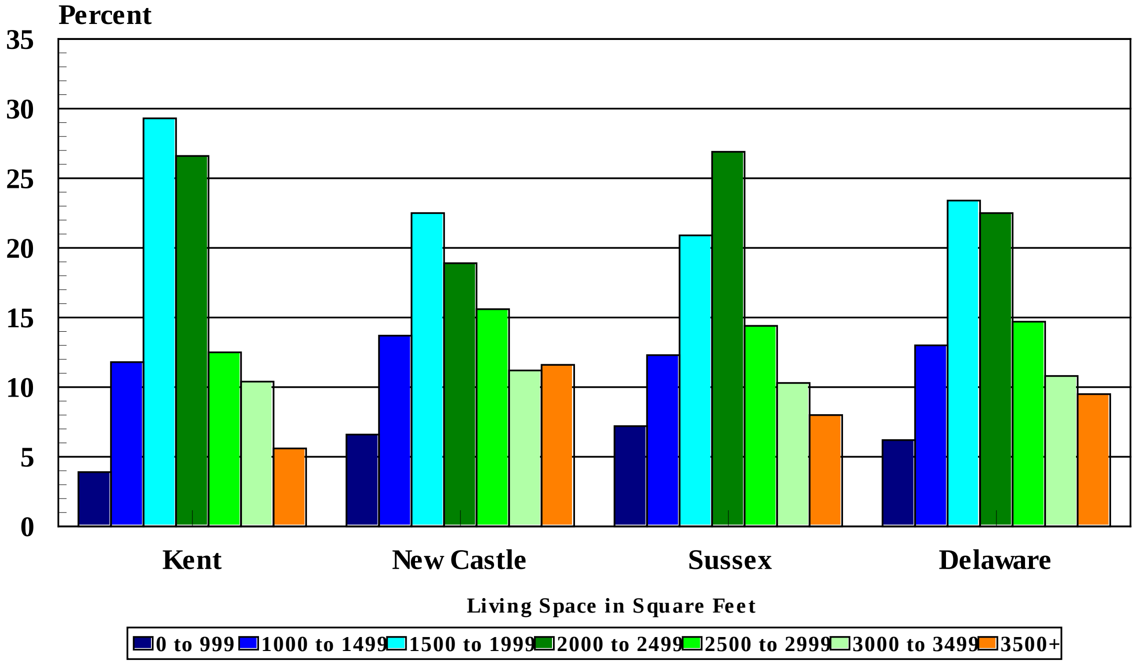


Source: Center for Applied Demography & Survey Research, University of Delaware

Yet another difference in the owner-occupied housing stock across counties emerges in Figure 1 - 7. Only 20% of dwellings in New Castle County have a single floor, while 58% in Sussex and 49% in Kent have a single floor ($ME_{.95}$ =4.83%). Manufactured homes explain only some of these differences. In addition, one-third of single family detached homes have a single floor and 15% of the single family attached homes have just one floor. Over 24% of single family attached homes have three floors, while just 6.5% of single family detached homes have three floors.

Clearly, differences in housing type, number of floors, and the presence or absence of a basement/attic will have an impact on the adoption of energy efficient programs. These county differences suggest that such programs should tailor their design and targeting to reflect different opportunities.

Figure 1 - 8 Square Footage of Housing Unit, by County

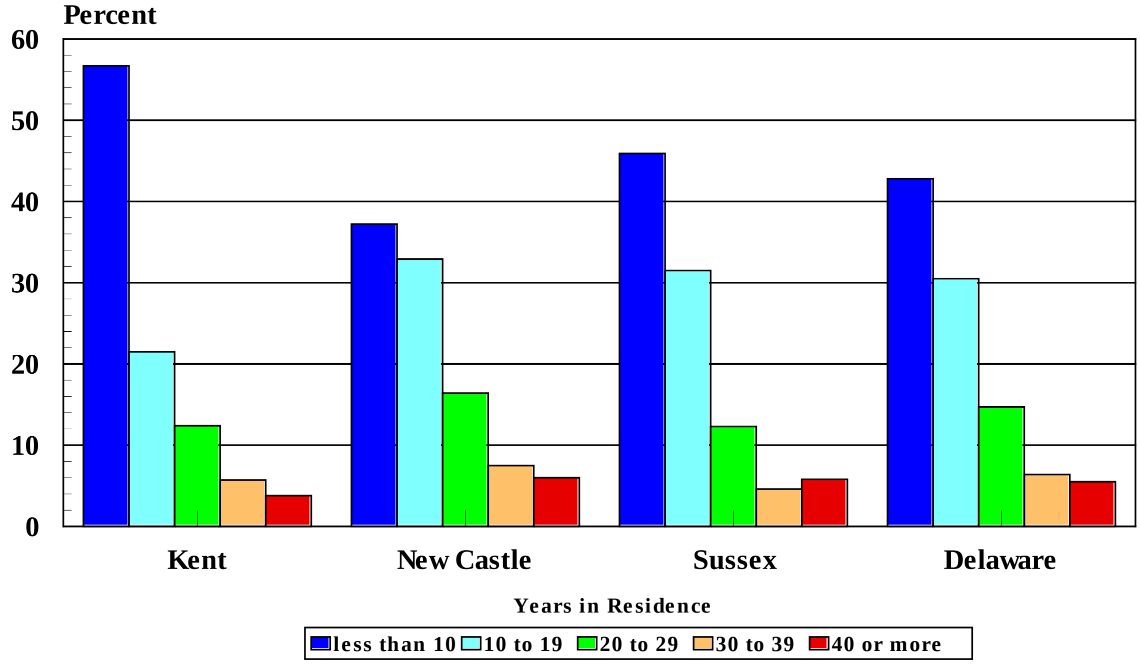


Source: Center for Applied Demography & Survey Research, University of Delaware

The distribution of the area of Delaware housing units (square footage) is found in Figure 1 - 8. The figure indicates that these distributions are similar, but not identical across counties. New Castle has a relatively flatter distribution. For example, the greatest proportion of housing units in New Castle is between 1,500 and 1,999 square feet (23%). In contrast, more than 25% of housing units in Kent County are of this size, and another 25% of housing units are between 2,000 to 2,499 sq. ft. However, the area of the average housing unit is not statistically different across counties.[5]

[5] The average area is 2,114 sq. ft. in Kent, 2,193 sq. ft. in New Castle, and 2,123 sq. ft. in Sussex.

Figure 1 - 9 Years Living in Housing Unit, by County

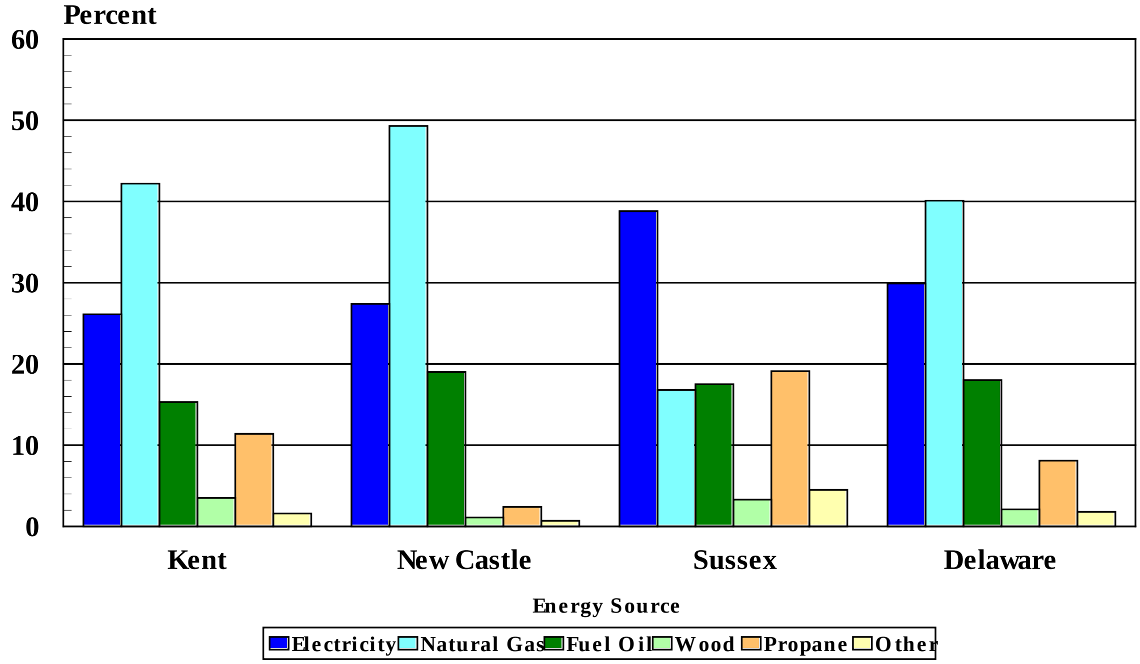


Source: Center for Applied Demography & Survey Research, University of Delaware

The final question addressed in this section is the length of time that homeowners have lived in their current housing unit. Recent movers are more likely to perform residential remodeling projects. Figure 1 - 9 indicates length of residence categorized in 10 year groups. More than half of Kent County homeowners lived in their homes for less than 10 years, and more than 70% of homeowners have lived in their unit for less than 20 years.

People living in their homes for 30 or more years overwhelmingly said that they are not planning on moving in the next two years. As expected, homeowners in this group are older Delawareans. The average age in the 30-39 group is 59.7 years and the average age in the 40+ group is 77.7 years. Between 8% and 10% of the 0-29 year residents say that they are likely to move in the next two years. That implies that every year you would expect to see between 4% and 5% of the first three groups move to a different house.

Figure 1 - 10 Energy Source for Heat, by County



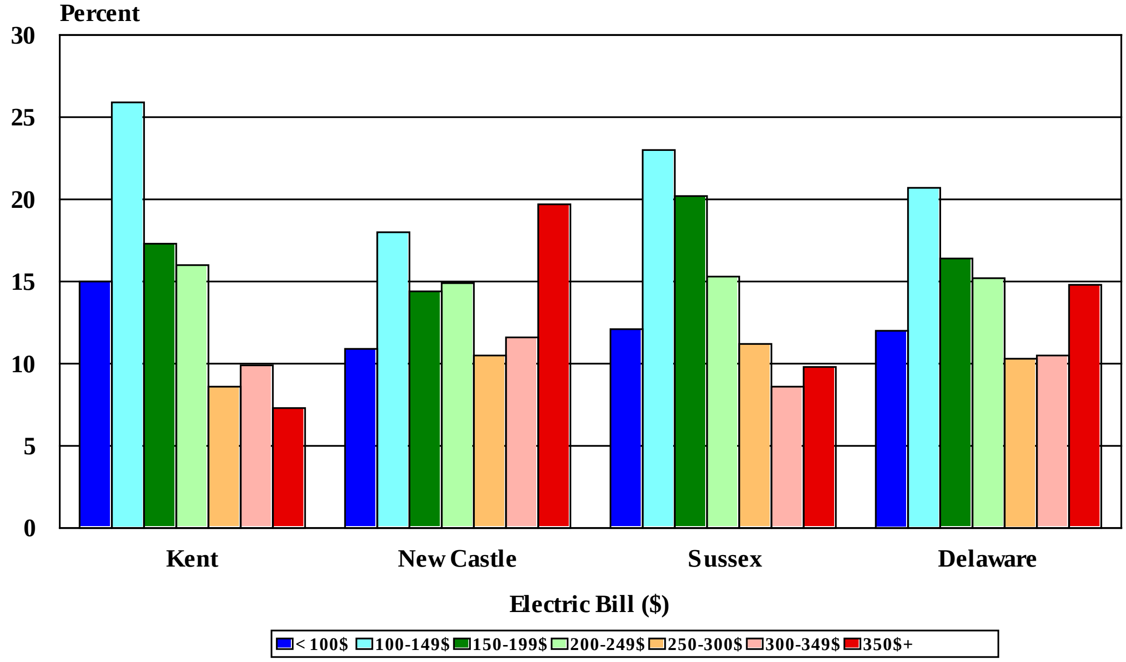
Source: Center for Applied Demography & Survey Research, University of Delaware

Energy Characteristics

The type of energy source used to heat homes is important to energy efficiency in at least two ways. First, some energy sources are more efficient in creating heat, such as oil and natural gas furnaces. Second, since energy prices are as important to energy costs as the amount of energy consumed, knowing which residents rely on which energy sources for heat is important to financial considerations of the homeowner.

Figure 1 - 10 shows that 40% of Delaware's owner occupied housing units are heated by natural gas, 30% by electricity, and 18% by fuel oil. In Sussex County the primary source for heat is electricity. Natural gas is used significantly less in Sussex, because the distribution system is not as widespread as found further north. Instead, propane is the second most prevalent source in Sussex. Propane is also important to a large proportion of homeowners in Kent County.

Figure 1 - 11 Most Recent Electric Bill, by County

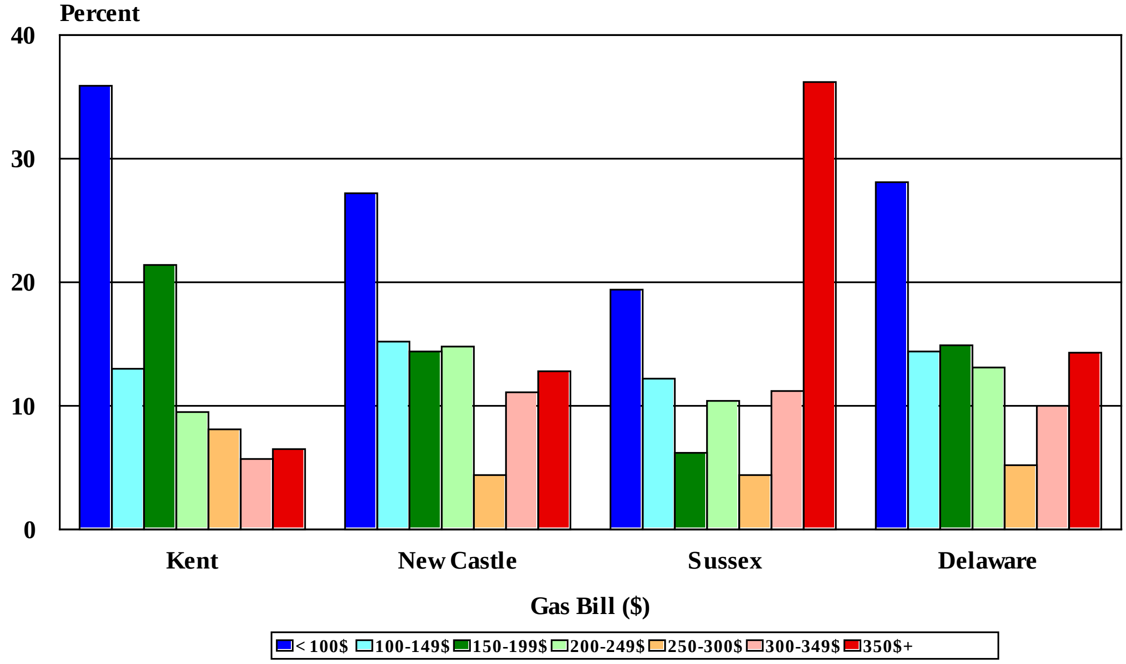


Source: Center for Applied Demography & Survey Research, University of Delaware

The homeowners were also asked to provide the amount of their most recent electric bill. Since this survey was conducted over about a year, the amounts average across more intense heating and cooling periods. On average, our survey found that average monthly bill for the state was $222.75. By county, the average bill was $189.57, $240.10, and $209.11 for Kent, New Castle, and Sussex respectively. Kent and Sussex are not significantly different from each other, but both are significantly different from New Castle ($ME_{.95}$ =$14.28).

The distribution of these bills by county is shown in Figure 1 - 11. Kent and Sussex counties have proportionally more households in the lower end of the scale. New Castle has nearly double the percentage of homeowners with monthly electric bills above $350 than Sussex. Of course, only some of this electricity use is attributable to heating, and we expect that other factors explain these differences. For example, households with incomes of $35,000 have monthly bills that are about $100 less than households with incomes of $150,000.

Figure 1 - 12 Most Recent Gas Bill, by County

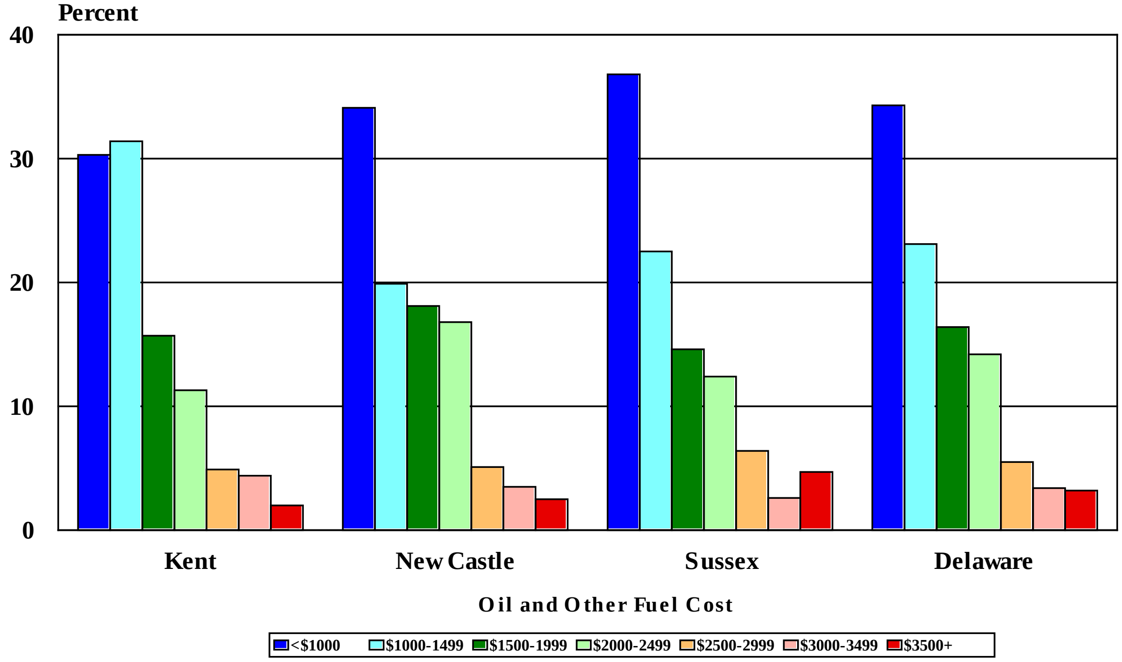


Source: Center for Applied Demography & Survey Research, University of Delaware

Similarly, homeowners were also asked to provide the amount of their most recent gas bill, and the average gas bill for the state was reportedly $207.57. Again, we expect that these values reflect average monthly bills, since the survey was conducted uniformly over about a year. The average gas bill was $165.51 in Kent, $199.39 in New Castle, and $324.55 in Sussex, respectively. Kent and New Castle are not significantly different from each other, but both are significantly different from Sussex ($ME_{.95}$ =$37.78). The median gas bill in Sussex was $270 and there are some very high bills reported.

Figure 1 - 12 plots the distribution of gas bills by county. Like the electric bills, there are very large differences between counties. Both Kent and New Castle have more bills weighted toward the lower end of the scale, but Sussex has more than triple the percentage of gas bills in the highest category. The reason is not readily apparent other than the high cost of propane or a statistical anomaly.

Figure 1 - 13 Annual Cost for Other Fuel, by County

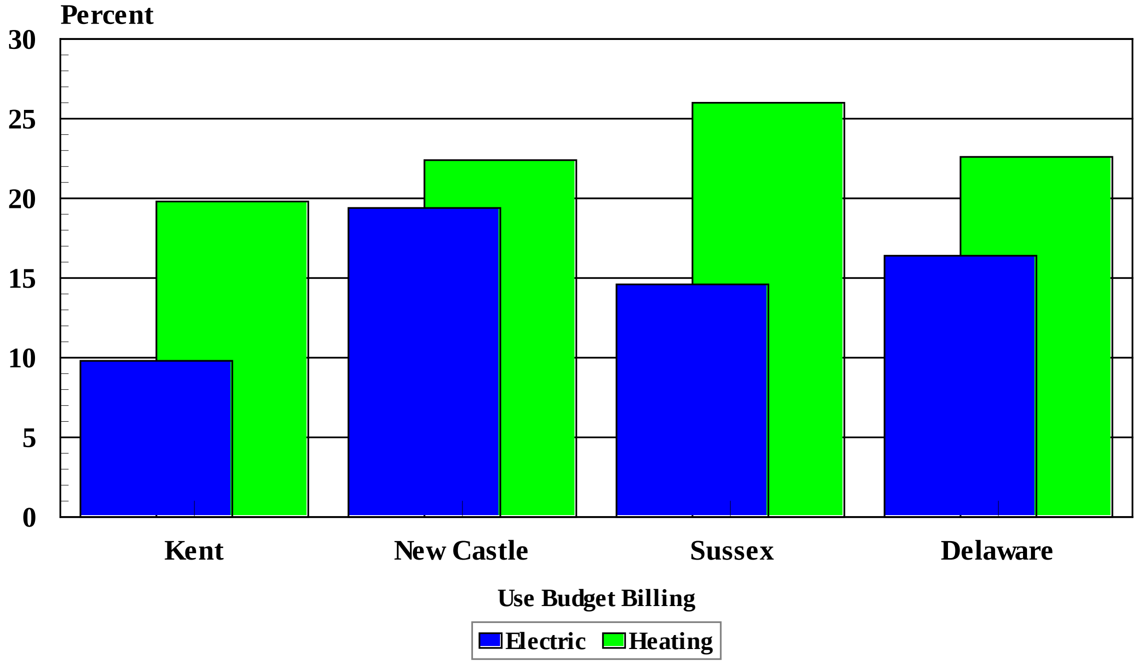


Source: Center for Applied Demography & Survey Research, University of Delaware

Finally, homeowners were asked to estimate their annual cost for fuel oil or any other energy source. The average annual fuel bill for the state was $1,392.50. The average annual fuel bill in the counties was $1,340.73, $1,424.66, and $1,378.93 for Kent, New Castle, and Sussex respectively. None of the counties was significantly different from the other ($ME_{.95}$ =$141.5). Figure 1 - 13 shows the distribution of fuel bills. The figure shows that there appears to be remarkable consistency across the counties in the shape of the distributions as well as the averages.

Figure 1 - 14 indicates whether the homeowner currently uses budget billing for either their gas or electric bills. Presumably, persons on budget billing will be less sensitive to energy use, since the pain of paying higher costs for energy intensive months can be spread out over the whole year. Surprisingly, the survey indicates that only about 16% of homeowners in the state use budget billing for electricity and 23% do so for heating.

Figure 1 - 14 Use of Budget Billing, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

There is some variation among the counties, as both Kent and Sussex county homeowners are significantly more likely to use budget billing for heat than for electric ($ME_{.95}$ =3.53%). However, approximately 82% of those who budget for electric also budget for heat. In Kent County 70.9% of those that budget energy bills do both. In New Castle, 85.7% of budgeters do so for both heating and electricity. In Sussex that figure is closer to 77.3%. In addition, results from our survey implythat low income and high income homeowners are less likely to budget, but middle income homeowners are. Keep in mind that utility companies will often require that customers meet eligibility requirements before being accepted into budget billing. Budgeting is important to energy efficiency, because an effective payment has already been set. Savings due to reduced energy use are not immediately felt by homeowners on budget-billing.

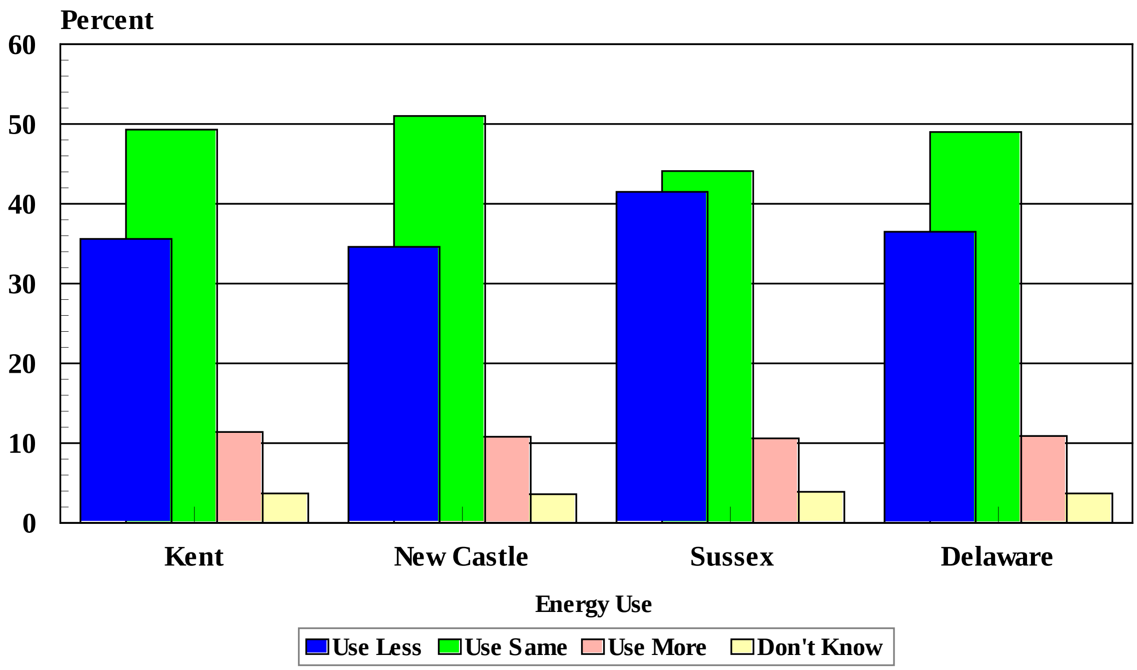
In the next section of the report, the homeowner's current behaviors to energy efficiency and pollution are addressed.

Current Energy/Pollution Behavior

This section reports the responses to survey questions intended to gauge perceptions of energy use and pollution reduction. Consumer actions ultimately matter in generating the demand for green products and services (and subsequent labor demand), however, people often act on their perceptions. Thus, it is fruitful to understand how households think about 'going green' in general and saving energy in particular.

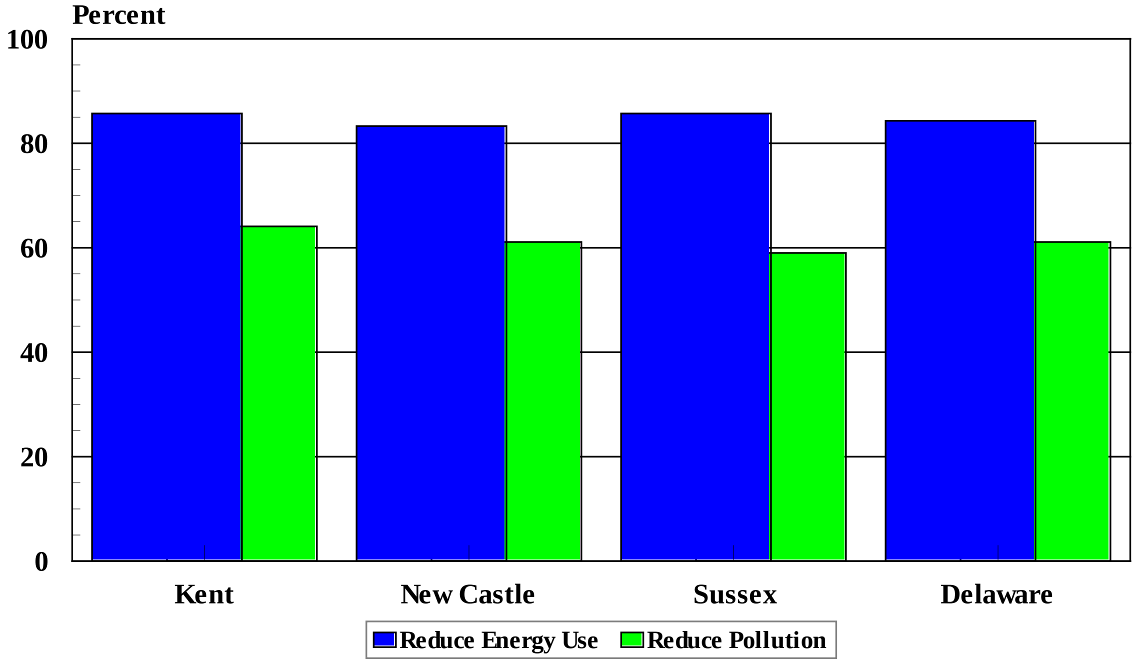
The information provided in Figure 2 - 1 suggests that more than a third of Delawarean homeowners think they use less energy than other neighboring homeowners. Almost 50% estimate that they are on par with their neighbors, and just over 10% believe they use more. Statistically speaking, there is no real difference between counties.

Figure 2 - 1 Use Less Energy than Neighbors, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

Figure 2 - 2 Try to Reduce Energy Use and/or Pollution, by County

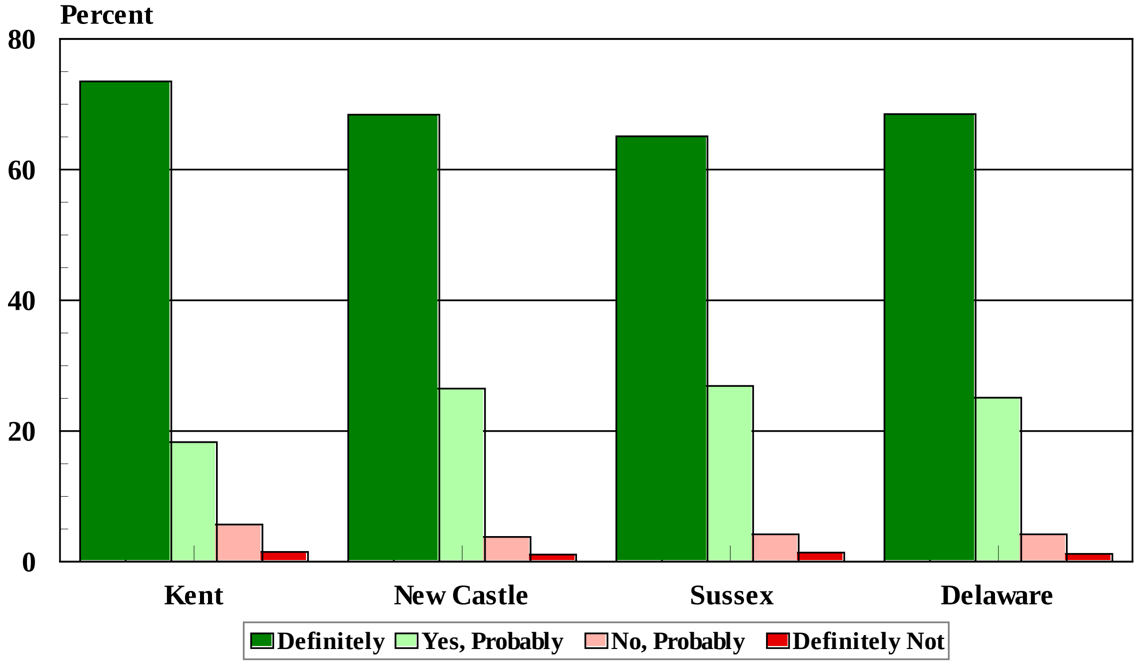


Source: Center for Applied Demography & Survey Research, University of Delaware

The next question asked homeowners whether they performed any actions meant to reduce energy use and whether any other actions were taken to reduce pollution. Slightly more than 80% of homeowners said that they are actively doing activities to reduce their energy consumption, while 60% said that they are also taking additional steps to reduce pollution. Thus, the overwhelming majority of the population believes that they are already engaged in green activities. A small percent of homeowners appear indifferent to saving energy. Just 2% thought they likely used more power than their neighbors and were not trying to conserve.

Homeowner perceptions on the amount of energy being used (relative to one's neighbors) are only slightly related to whether homeowners think they engage in energy-saving activities. Approximately 90% of homeowners who said they used less energy than their neighbors also said that they actively tried to reduce their energy use. By comparison, 80% said they used the same amount or more energy than their neighbors and they were actively tried to reduce their energy use.

Figure 2 - 3 Reducing Energy is a Worthwhile Goal?, by County

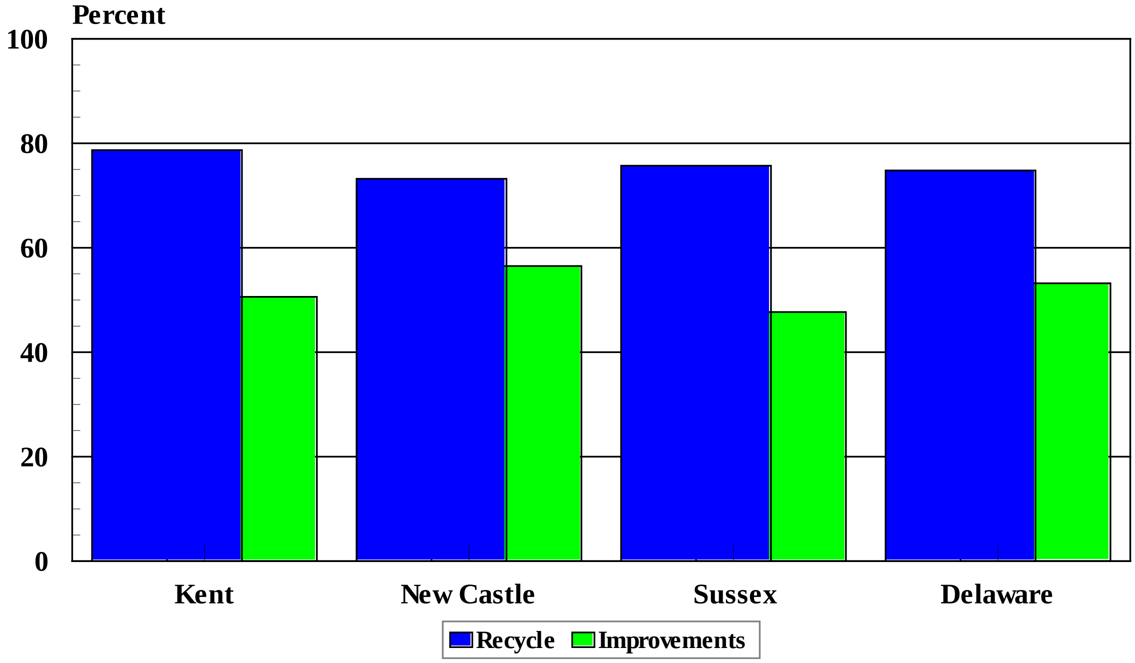


Source: Center for Applied Demography & Survey Research, University of Delaware

When homeowners were asked directly whether they thought reducing energy use was a worthwhile goal, nearly 70% said they are in definite support of the goal and another 25% are in probable support. Thus, Delaware homeowners appear sold on the idea of saving energy, at least at face value. In fact, 90% of those who said they were definitely committed to the goal said that they were actively trying to reduce energy use. On the other hand, 46% of those homeowners not in definite support of this goal said they were also not actively trying to conserve energy. This illustrates that other economic and behavioral factors likely interfere with stated intentions of households.

The next three charts illustrate some of the actions the typical homeowner could undertake to improve energy efficiency or reduce pollution.

Figure 2 - 4 Recycle at Home? Any Improvements in Last Two Years?, by County

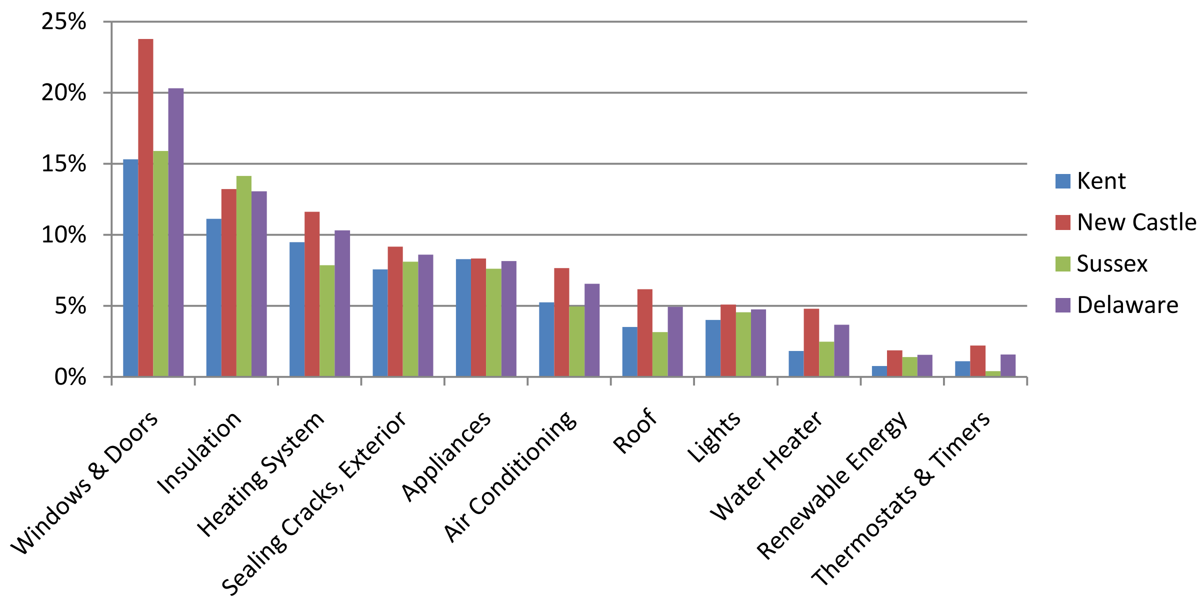


Source: Center for Applied Demography & Survey Research, University of Delaware

In Figure 2 - 4, the prevalence of recycling and home improvements is displayed. The figure shows that slightly less than 80% of homeowners are engaged in recycling at some level. Of course, recycling is largely voluntary until July 2011. After this time, homeowners in most of the state will be charged for the service even if they chose not to recycle. This incentive will likely encourage many more households to recycle.

The second question, which asks respondents if they have engaged in any home improvements in the last two years, receives an affirmative response from 53.8% of the homeowners. Figure 2 - 4 also indicates the percentage of homeowners performing different types of energy saving improvements.

Figure 2 - 5 Type of Home Improvements

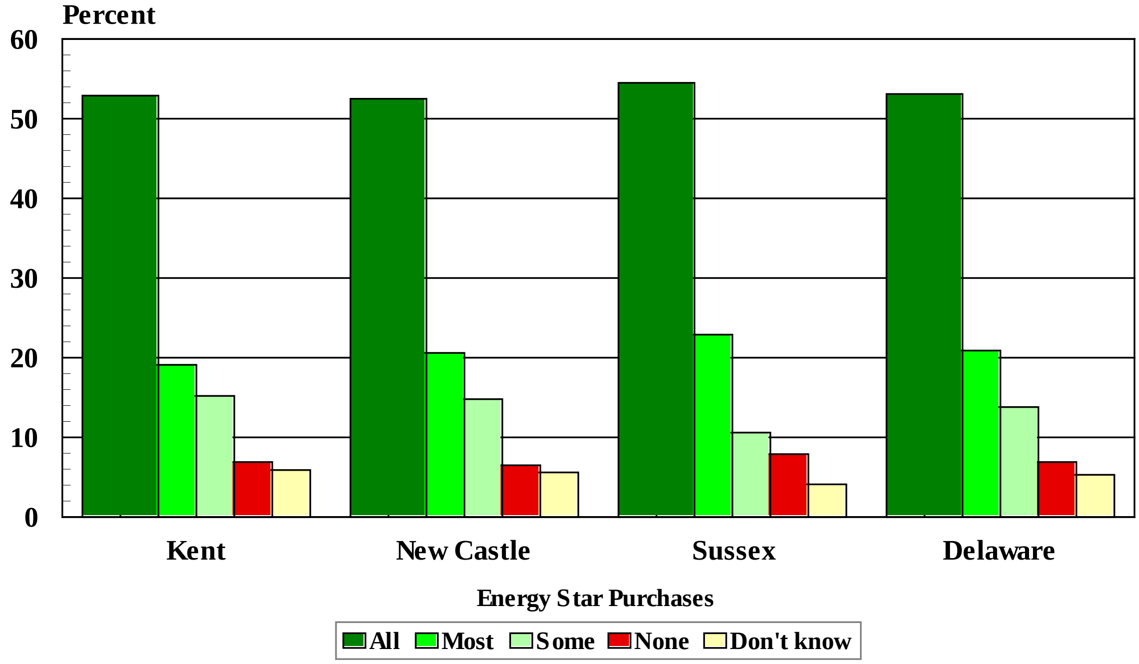


Source: Center for Applied Demography & Survey Research, University of Delaware

Figure 2 - 5 reports what type of home improvement projects homeowners said they performed in the last two years in order to save energy. Windows and doors were the most common response, followed by insulation projects, and then heating systems projects. Sealing cracks in the walls, improving the exterior of the home, and adding storm doors or storm windows were the fourth most common project. Approximately 3.7% of homeowners reported installing a new energy efficient water heater in the last two years, which is more than double the number of homeowners who reported performing a renewable energy project (including solar PV, solar heat and hot water, and geothermal HVAC systems).

Except for projects involving windows and doors ($ME_{.95}$=4.5%) or water heaters ($ME_{.95}$=1.8%) New Castle homeowners were no more likely to report one of these projects than homeowners in the other two counties. Homeowners in definite favor of reducing energy efficiency were three times more likely to have done a home improvement than those who were definitely not in favor of that goal.

Figure 2 - 6 Purchase ENERGY STAR Appliances?, by County

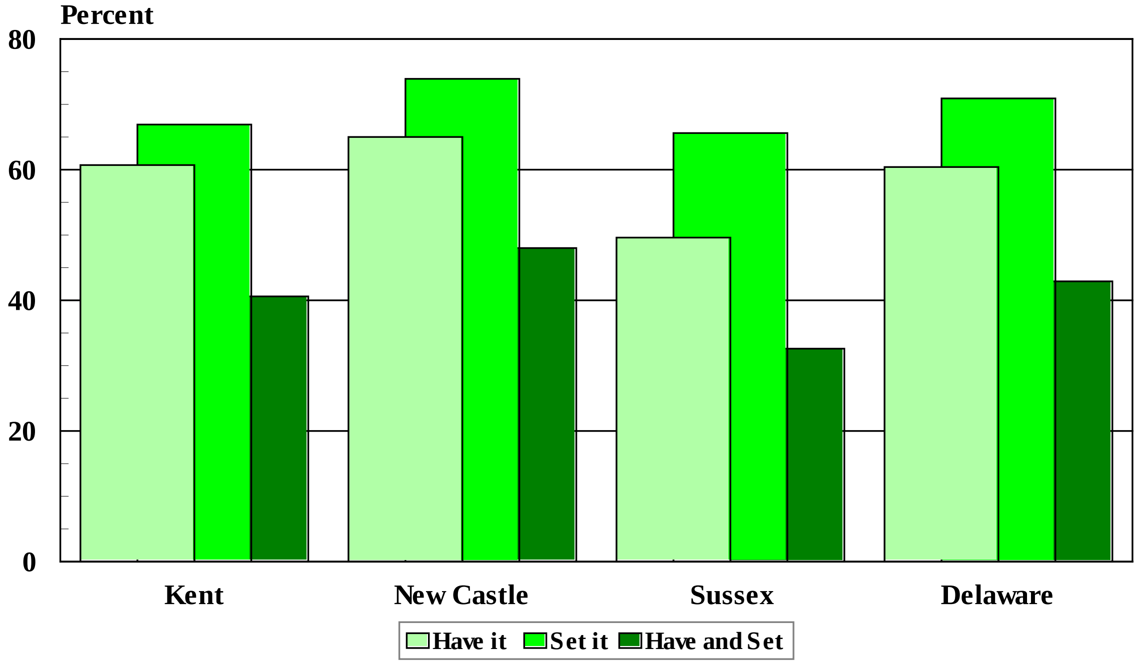


Source: Center for Applied Demography & Survey Research, University of Delaware

ENERGY STAR appliances have been around for years and most homeowners are aware of their presence. In general, energy star qualified appliances are generally more expensive initially, but are expected to save money in the long run. Figure 2 - 6 indicates whether the homeowners routinely think about the ENERGY STAR rating when purchasing the appliance.

Slightly more than 50% of Delaware's homeowners look for appliances with the ENERGY STAR rating. An additional 20% consider the ENERGY STAR rating for most appliances. Less than 10% of homeowners do not consider the rating at all. For all practical purposes, county does not appear to play a role in these decisions. Income, on the other hand, may. About 40% of homeowners at the low end of the income distribution said that they would purchase ENERGY STAR appliances all of the time, and nearly 60% at the top of the distribution said the same. However, that difference is not statistically significant.

Figure 2 - 7 Have a Programmable Thermostat? Set it?, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

The last question in this section asks households if they have a programmable thermostat that can control the home's temperature at different times of the day. For those that have such a device, a follow up question asked if it was used. Figure 2 - 7 indicates that 60% of Delaware's homeowners have such a device, and that 75% of them use it to control the daily temperature in their home. Collectively, this means that 42% of all homeowners are enjoying the energy savings of this relatively inexpensive device.

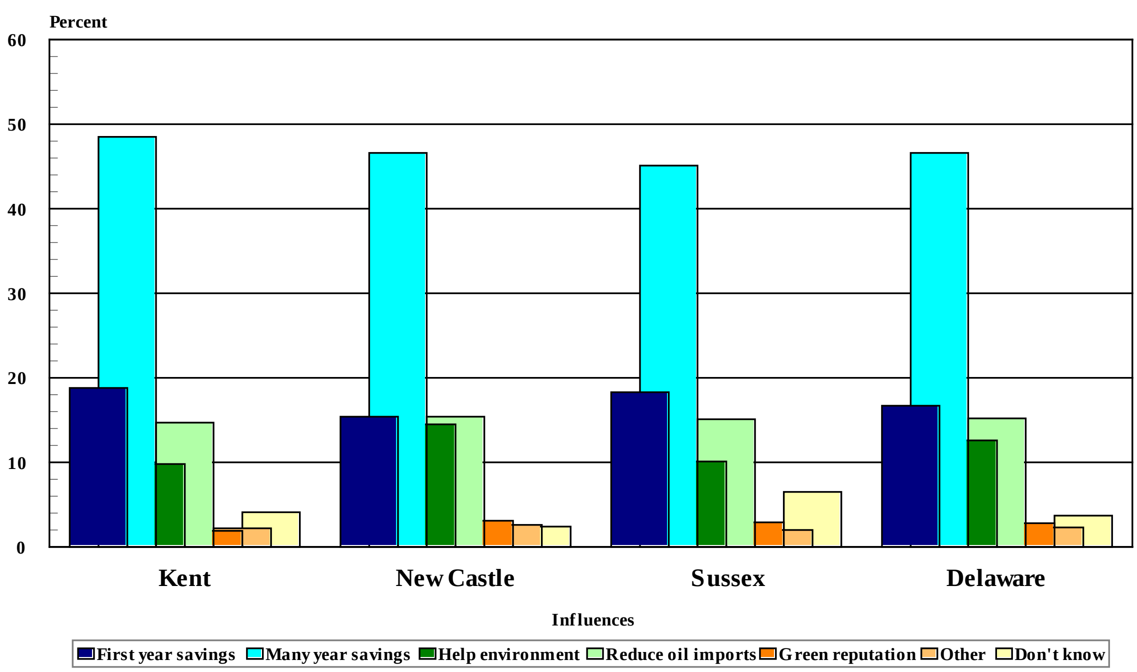
Given the ease and inexpensive way that this device reduces energy costs, we find it surprising that they are not utilized more frequently. In fact, programmable thermostats were the rarest type of home improvement projects performed in Delaware. How strongly one is in favor of conserving energy is not statistically related to thermostat use. Higher income homeowners are more likely to have and set a programmable thermostat than are lower income homeowners.

Financial Considerations

Making a commitment to invest in an energy saving home improvement is a complex matter. Households can spend their money in different ways, and like anything else, energy-efficient projects must compete for scarce resources. This section deals with the financial considerations of a household's decision to invest in energy-efficiency.

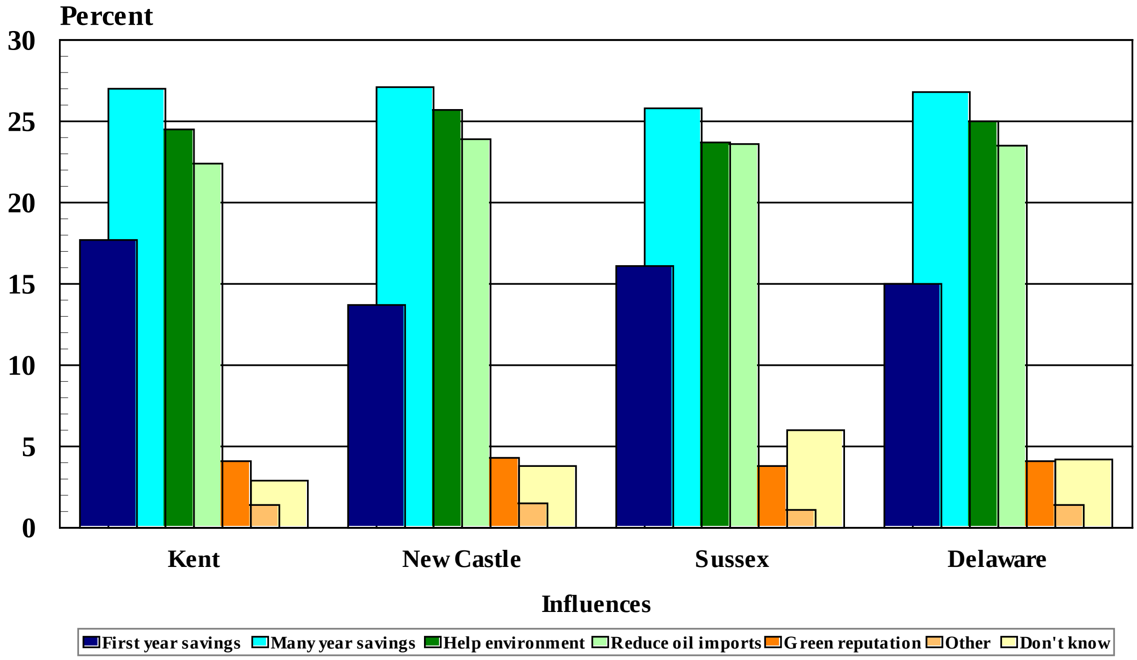
There are many reasons why a household might want to perform an energy efficient investment. The stream of lowered energy costs in the future is the most obvious benefit, but so too are other issues such as concerns for the environment and energy independence. Figure 3 - 1 reports which benefits households consider to be most important to investing in energy efficiency.

Figure 3 - 1 Primary Factors that Influence Energy Use Investments, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

Figure 3 - 2 Secondary Factors that Influence Energy Use Investments, by County

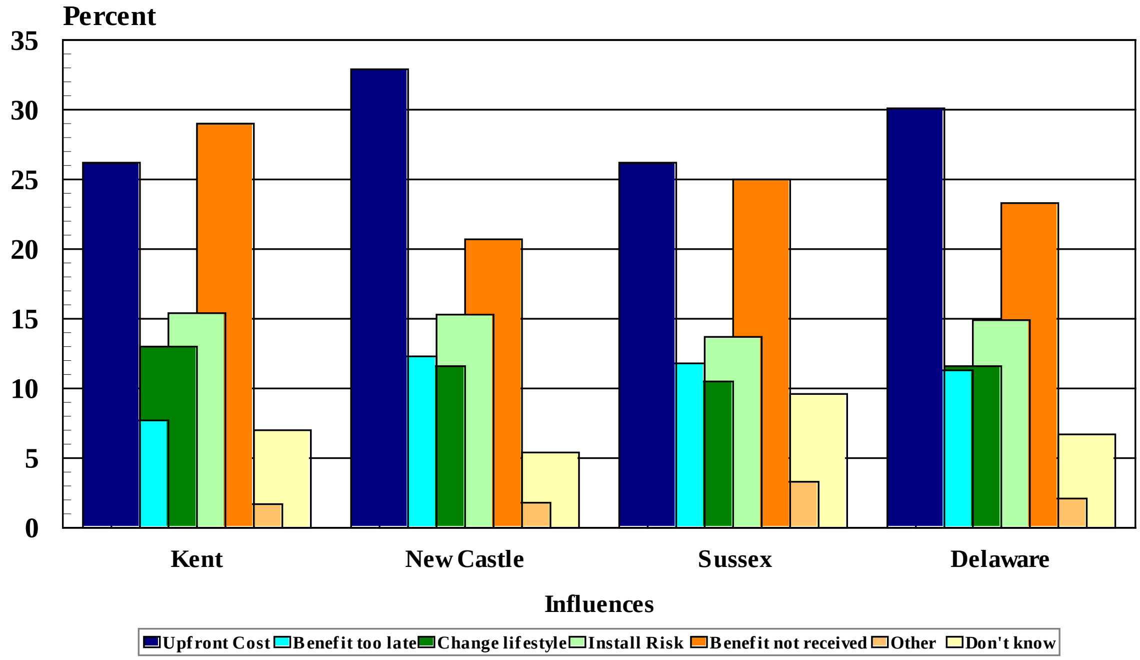


Source: Center for Applied Demography & Survey Research, University of Delaware

It is hardly surprising that the dominant factor is the multi-year savings, and the second most dominant factor is the monetary savings occurring within the first year. The non-monetary benefits are more social in nature, less tangible, and generally difficult to quantify. Thus it is no surprise that households instinctively rank these factors below the financial ones.

Next, homeowners were asked for the second most influential benefit of making a home improvement decision that would save energy, and they were not permitted to provide the same answer as before (see Figure 3 - 2). Those that selected "*first year savings*" as the most dominant factor selected multi-year savings as the second-most important factor. In fact, multi-year savings is still the most prevalent response, even though the non-financial factors are chosen at much higher frequency. Approximately 38% of those that initially selected *multi-year savings* chose *helping the environment* as the second most important factor, and 32% reported that *reducing oil imports* was the second most important factor.

Figure 3 - 3 Primary Factors that Influence Energy Saving Investments Negatively, by County

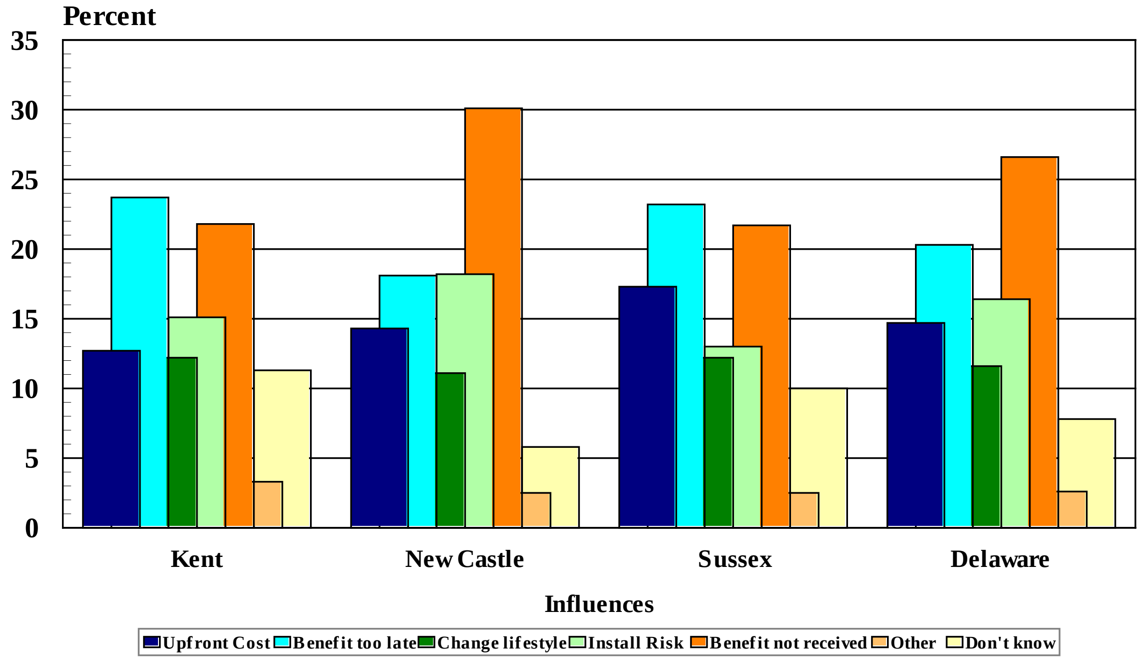


Source: Center for Applied Demography & Survey Research, University of Delaware

Those that initially selected one of the social benefits as the dominant factor were most likely to choose multi-year savings as the second most important factor. Thus, the decision to save energy appears to be dominated by financial rather than the social concerns.

The second part of this sequence focuses on the reasons for not making the home improvement investment. Because households were overwhelmingly influenced by the financial benefits of saving energy, it is not too surprising that financial considerations are also the most dominant disincentive of energy saving home improvements. Figure 3 - 3 indicates that the upfront costs are the primary concern to households, followed closely by the risk that the stream of future financial benefits is going to be less than anticipated. The difference between these top two responses is significant ($ME_{.95}$ =2.55%).

Figure 3 - 4 Secondary Factors that Influence Energy Saving Investments Negatively, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

There is also variation in the financial considerations between the counties. In New Castle County, for example, there is more concern about the upfront costs than there is about receiving future benefits. Homeowners in Kent and Sussex counties are evenly divided between these two factors. Risk of improper installation, of the benefits arriving too late, or of the changes in the homeowners lifestyle are relatively less important in all three of the counties.

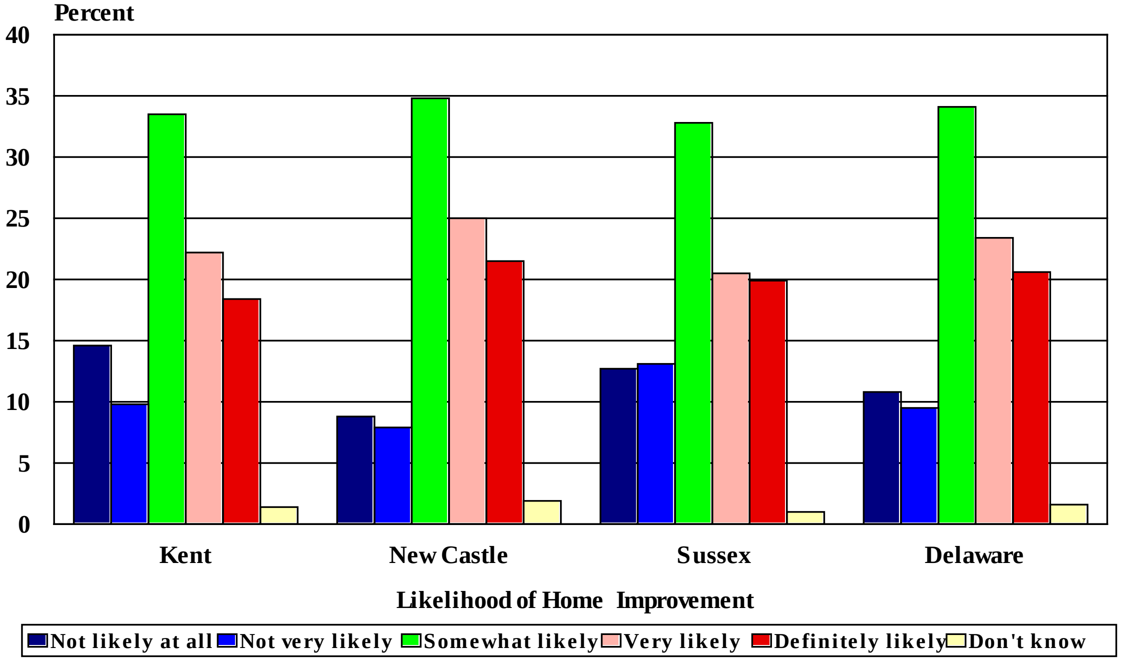
Following the pattern of the previous set of questions, homeowners were asked to list the second most important factor that would likely influence them not to make an energy-saving home improvement. The responses are summarized in Figure 3 - 4.

For the state as a whole, the focus shifts from *upfront costs* to *benefits not received in the future*, and this shift is heavily influenced by the homeowners from New Castle County. Kent and Sussex home owners were more likely to consider *benefits arriving too late* rather than not being received at all. All in all, the factors that were of most concern to homeowners were clearly financial in nature.

Based on the household's response to these questions, home improvements designed to save energy are not likely perceived in the same way that other home improvements are judged. For example, homeowners remodeling their kitchens or adding a room to their house are not doing so to save money, but rather for more immediate consumption. Benefits from energy efficiency improvements are not that immediate or always so tangible. Costs on the other hand are immediate and tangible, as is delayed gratification.

Thus, it is no surprise that energy saving home improvements are viewed as investments, and much like any investment, risks are imposed on the household. The risk that the investment does not payoff is evidently the most important factor, since homeowners overwhelmingly cited upfront costs, immediate savings, and expected future benefit streams (or lack thereof) are the most important factors affecting household decisions.

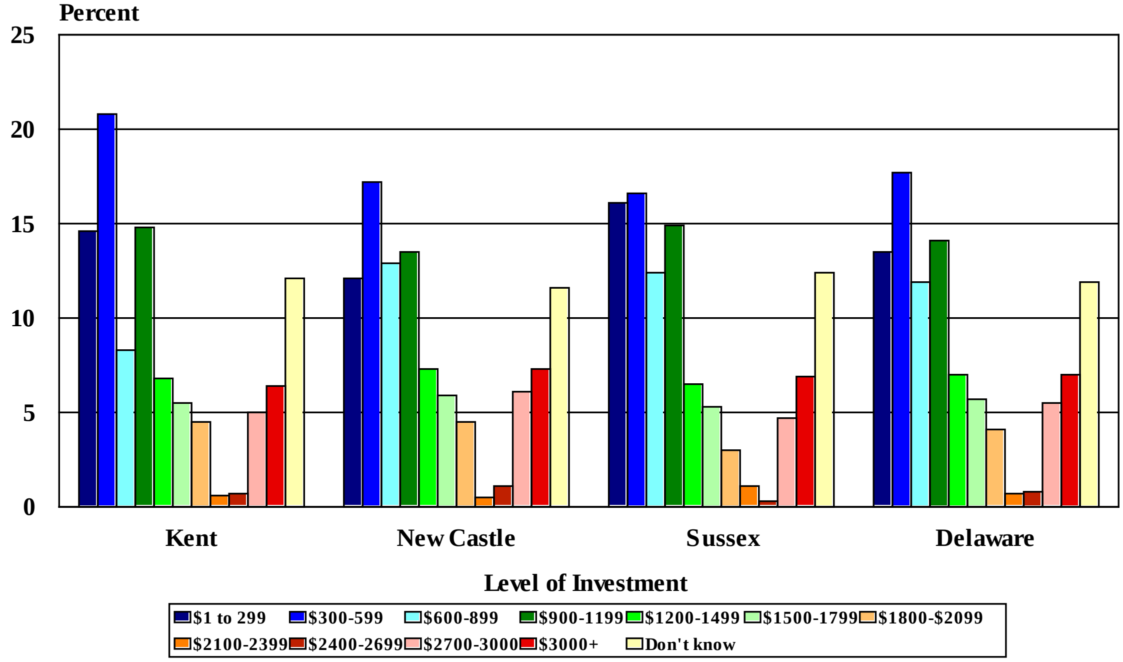
Figure 3 - 5 Undertake Home Improvements to Improve Energy Efficiency, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

Next, the survey asked homeowners how likely they are to undertake an energy saving investment in the future. The results are shown in Figure 3 - 5. The majority of homeowners in Delaware seem positively disposed to such a project; only 20% appear negative on the issue and 43% are strongly positive. However, nearly 35% are on the fence about making such improvements. There is no statistically significant difference between the counties. It should be noted that the question does not constrain the homeowner to any particular time period for the project.

Figure 3 - 6 Amount Willing to Spend to yield $3,000 in Five Years, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

In order to provide more information on the type of projects homeowners would consider, a hypothetical scenario was presented to the survey respondents. Homeowners were asked what upfront cost they would be willing to pay for an improvement that would yield $600 in annual savings over five years for a total of $3,000. Given recent low interest rates and diminished opportunities of investing in one's home, the responses should likely be in the upper $2,000's if homeowners viewed these projects like any other financial investment. However, the responses shown in Figure 3 - 6 indicate that most homeowners would not be willing to invest anywhere close to that amount.

The majority of responses to this question are oriented toward the lower end of the scale, and the average response for the state was $1,146. By county, the average responses were $1,101, $1,185, and $1,087 for Kent, New Castle, and Sussex respectively, though these were not statistically different from each other.

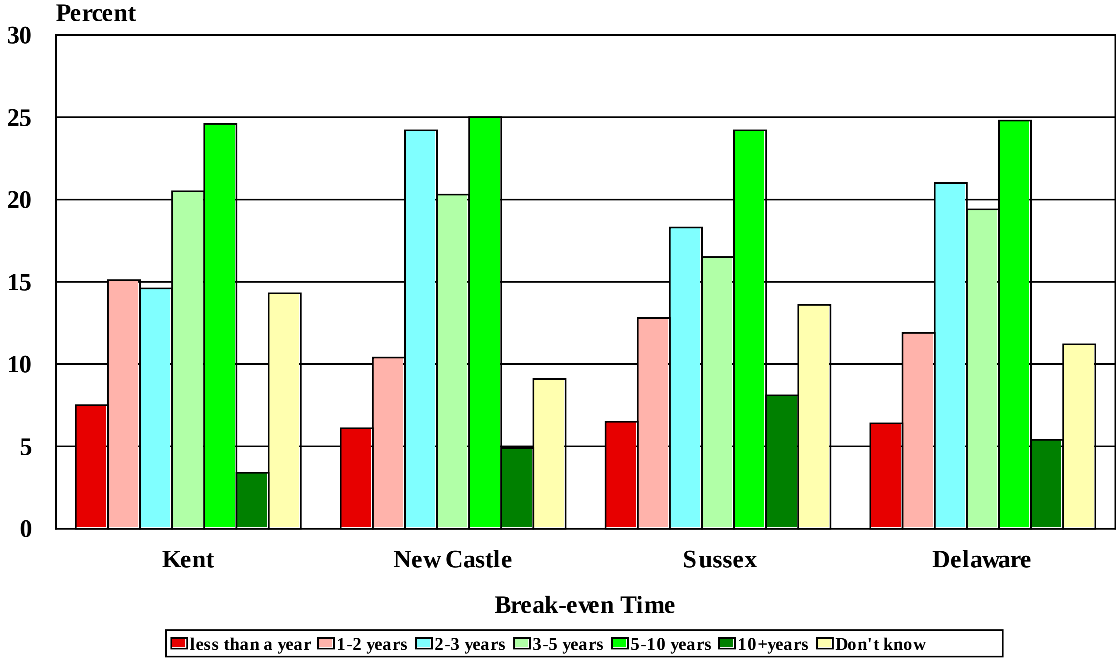
When the benefits are calculated monthly, these responses imply that the average homeowner expects annual percentage rates of 49.8% and annual percentage yields of 62.8% from energy saving investments. Stated another way, homeowners are only willing to wait approximately two years for the recover their upfront investments. Obviously the implied rate of return is far beyond what one might expect from typical investments.

The extremely high values imply that households likely view such investments as inherently risky. Given the historical price volatility in the energy markets, the likely implementation of revenue decoupling, and the risks involved with the project quality, such skepticism is not altogether unreasonable. Earlier charts showed that the upfront costs, the upfront benefits, the future benefit streams, and the risk that those benefit streams do not materialize are the most important factors affecting homeowners' decisions.

There are two reasons why these implied rates may be overstated. First, the question was purely hypothetical, and it is possible that homeowners' instinctual reaction is to extract as much as they can for themselves. If true, then when homeowners actually make such decisions, they may be willing to accept lower payments. Of course, in most surveys homeowners tend to *overstate* what they are willing to give up, and when it is time to pay, purse strings tighten. The second reason may be due to the scale of the hypothetical scenario. Since the average income of the respondents is $55,000, an upfront cost of $2,000-$3,000 might be beyond what most households are able to afford for a voluntary investment. For example, if the question had asked people of their decision regarding a $300 return over five years, answers might have been different.

Respondents were later asked how long they would be willing to wait before breaking even on an energy-saving project that returned benefits over a 10 year period. By stating the question in terms of time rather than dollars, income constraints can generally be ignored. The responses are summarized in Figure 3 - 7.

Figure 3 - 7 Time Willing to Wait for Energy Investment to Break Even, by County

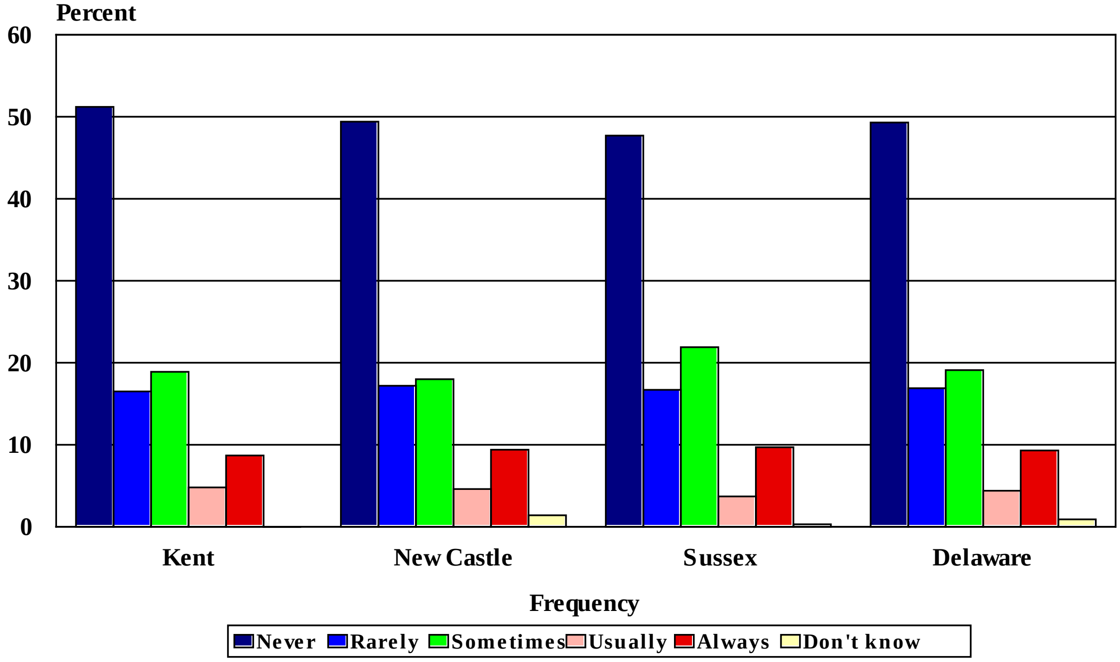


Source: Center for Applied Demography & Survey Research, University of Delaware

For the state as a whole, the median respondent answered that they would be willing to wait between 3 and 5 years. The average response in the state was 3.4 years. The average response by county was 3.2, 3.4, and 3.7 years for Kent, New Castle, and Sussex counties respectively. The counties were not statistically different from the state or each other.

These results are similar to the first scenario. In that case, respondents implicitly said they were willing to wait 1.9 out of 5 years to recover their investment costs. In the question posed above, the respondents were only willing to wait 3.4 out of 10 years for their costs to be recouped. This may indicate diminishing homeowner patience as the duration of an investment expands. Of course, this is natural given the time value of money. Such factors should be considered when designing programs involving larger upfront costs and longer payback periods.

Figure 3 - 8 Worried about Energy Bills in Last 12 Months, by County

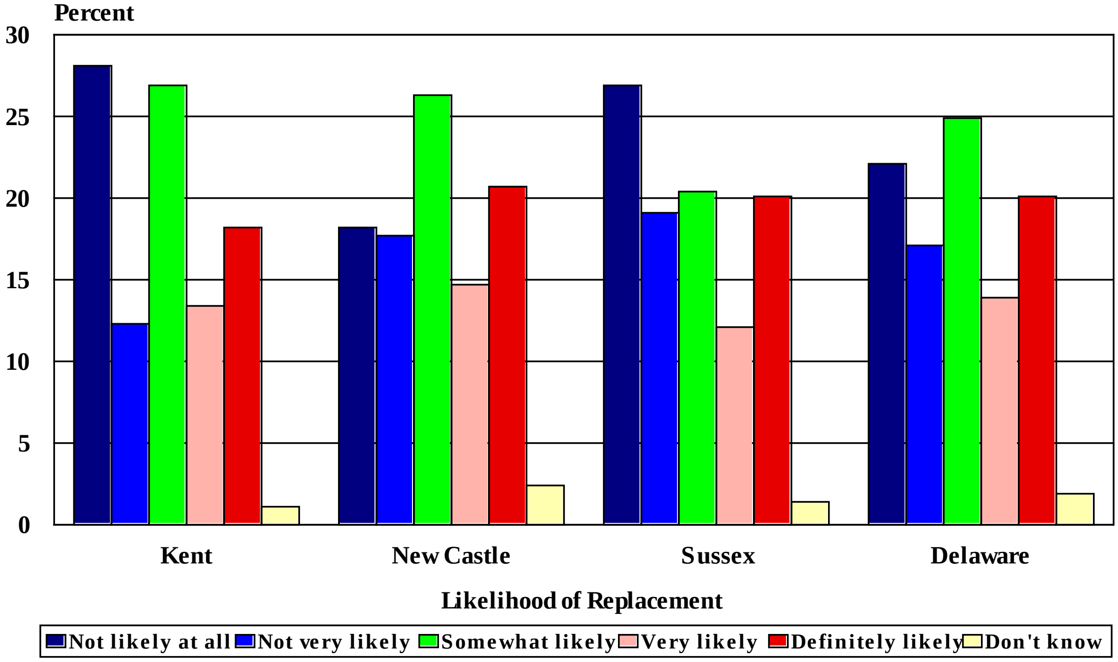


Source: Center for Applied Demography & Survey Research, University of Delaware

One reasonable explanation for low risk tolerance is that homeowners may feel that they cannot afford to devote any additional resources to lowering future utility bills. Therefore, we asked homeowners how often they worried about being able to afford their energy bills. Figure 3 - 8 indicates that 70% of the state's homeowners never or rarely worry about the size of their energy bills. This is consistent in all three counties; nearly 15% said they usually or always worry and almost 20% said that they sometimes worry about being able to afford their energy bills.

Looking at how important upfront costs were to making an energy-saving home improvement, there is a statistical difference between those who *never* worried and those that *always* worried about paying their energy bill. Those who were always worried about their current bills selected upfront costs 42.5% of the time, while those that were never worried selected upfront costs 25.9% of the time. Both issues are related to income levels, though some lower income homeowners never worry about their utility bills and some higher income homeowners always worry.

Figure 3 - 9 Replace a Working Appliance with a More Energy Efficient Appliance, by County

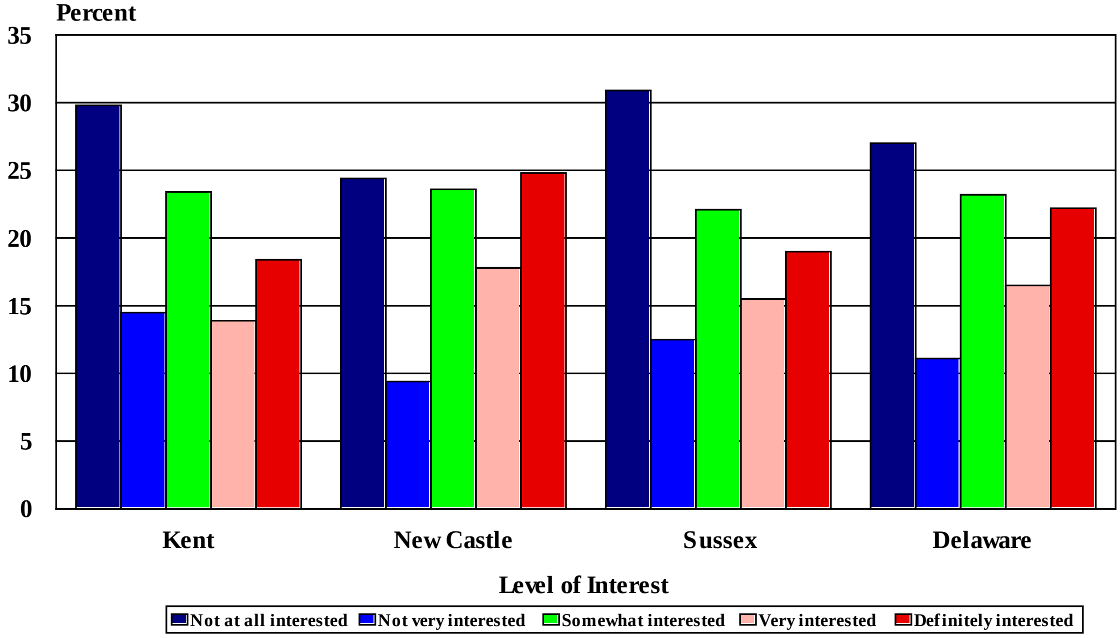


Source: Center for Applied Demography & Survey Research, University of Delaware

The last three questions in this section were designed to measure the respondent's feelings about taking more concrete steps to improve energy efficiency in their homes. The first question asks if the homeowner would replace a working appliance simply because a new one would be more energy efficient.

The responses in Figure 3 - 9 show a relatively large difference of opinion in the state. About 40% of the homeowners have little or no interest in replacing a working appliance and almost 35% appear ready to do just that. The difference between the two segments of the distribution is not statistically significant. Nearly a quarter of the respondents were ambivalent. There are a few differences between the counties, particularly between lower Delaware and New Castle County, but the differences are neither substantive nor statistically significant. Homeowners that said they would replace a working appliance were more likely to have made a home improvement in the last two years (61%) than those who said they would not replace a working appliance (46%).

Figure 3 - 10 Measuring Appliance Power Cost, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

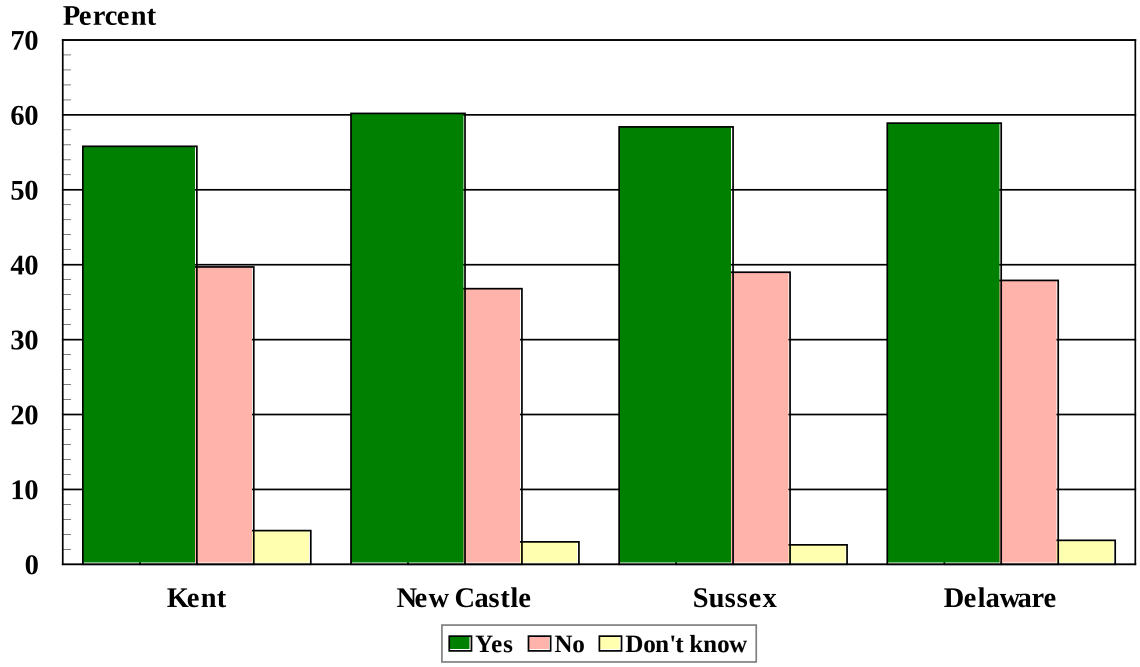
The next question asked homeowners if they were interested in a device which could measure the power used by any particular appliance. Similar to the previous question, Figure 3 - 10 shows that there does not appear to be a consistent answer to this question. Approximately 38% of homeowners have little or no interest in measuring the power of any particular appliance, and another 38% have a relatively high level of interest. In general though, the *not at all interested* respondents were more common than respondents that were *definitely interested.* The difference between these two types of responses was significant in both Kent and Sussex counties. Such behavior indicates that many homeowners, particularly in the lower portion of Delaware, may not be willing to exert much effort to try and understand *why* their energy consumption is what it is.

The final issue in this sequence addresses the very real opportunity for homeowners to monitor their use of electricity and its cost in real time. Smart meters are considered green because they allow homeowners to respond to hourly adjustments in the electricity price. The idea is that by spreading usage out over the day, peak loads can be reduced.

On the one hand, high peak loads are economically inefficient because proportionally higher power loss occurs during transmission when load increases and because more non-baseline generation costs are generally more expensive than baseline generation costs. Smoothing power demands increases the relative amount of power that can be supplied using cheaper, baseline sources. Of course, these cheaper baseline power sources are primarily coal and nuclear so there is effectively a tradeoff between environmental and economic benefits.

On the other hand, smart meters can make electricity costs more tangible to households, provided households look at those costs. Because the tangibility of those costs will likely *reduce* total consumption, it is possible that the total demand reduction will offset any negative environmental effects of smoothing the baseline load. The actual effect on household costs and the environment is an empirical issue deserving of more rigorous analysis than what can be covered in a survey of household behavior. However, homeowner use of these meters will play a crucial role.

Figure 3 - 11 Monitoring Real-time Electricity Cost, by County

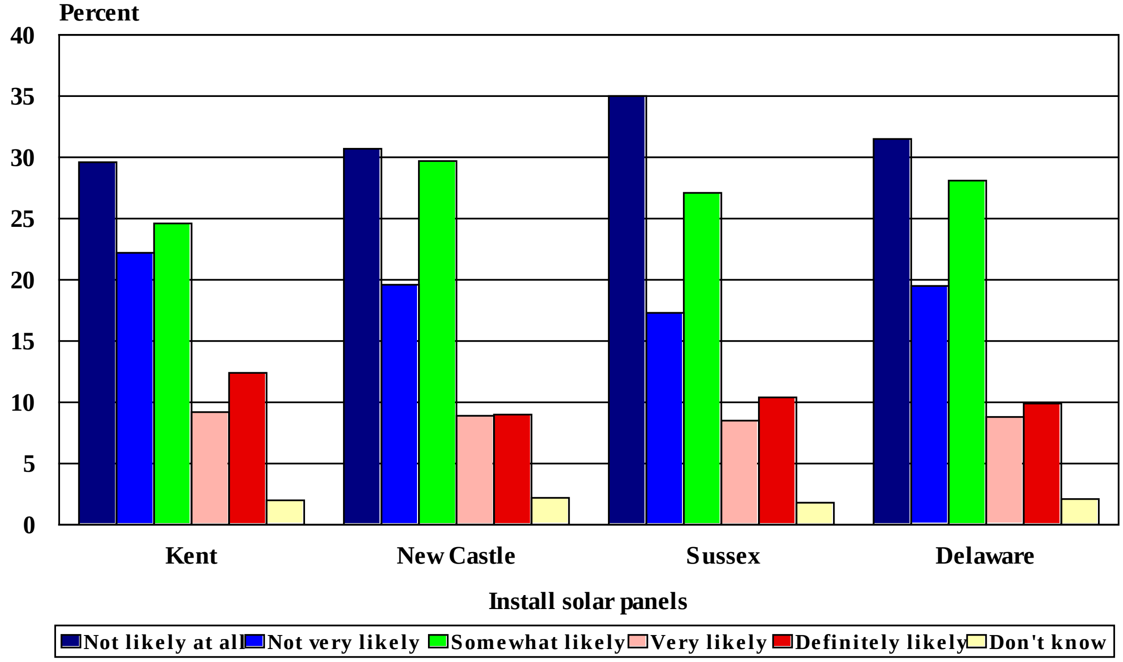


Source: Center for Applied Demography & Survey Research, University of Delaware

Figure 3 - 11 indicates that 60% of homeowners expressed an interest in having a device tell them their real time electricity usage and costs. There are a number of reasons why this is not higher. First, some homeowners may have thought they would have to pay for such a device while other homeowners may have thought that it would be given to them for free. Still some households may express a lack of interest because they are not sensitive to short-run changes in electric costs, e.g. budget billing or those that have routinely small electric bills. Other households may feel that the behavioral costs of responding to such energy savings are not worth the financial savings, and they do not want to be constantly reminded of the costs of their decision. This would be especially true if electricity is a normal good, as most others are.

A quick analysis of the overall belief in the energy reduction goal shows that 32.2% of those who thought reducing energy was not a worthwhile goal were still interested in monitoring electricity costs. In contrast, 64.1% of those who thought reducing energy was a worthwhile goal were interested in monitoring electricity costs in real-time.

Figure 3 - 12 Homeowner Interest in Installing Solar Panels, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

Lastly, the homeowners were asked to assess their interest in installing solar panels on their homes. There are significant financial issues associated with this decision, involving large upfront costs and lengthy break-even periods. However, there are also large financial subsidies available to qualified households. Figure 3 - 12 shows that just less than 20% of the state's homeowners express significant interest in solar panels, and the distribution of responses is similar across the three counties.

Of course, lowering energy demand and switching energy supplies are two very different issues, both economically and environmentally. Approximately 20% of households with low income (0-$45K), medium income (45K-100K), and high income ($100K+) expressed interest in solar panels. The rub is that economic factors can be in direct conflict with perceptions. According to the JEDI model created by the National Renewable Energy Laboratory, a typical 4KW residential solar PV system costs $39,500. Even if a large portion of that cost is paid by others, very few low and medium income families can afford such a system.

We suspect that these misperceptions of the economic reality of solar PV are due to the strong connection people have made between energy efficiency and renewable energy. Over 87% of those that believed reducing energy consumption *was not a worthwhile goal* were also not interested in solar panels. By comparison, 25% of those saying that reducing energy use *was a worthwhile goal* also indicated an interest in solar panels. This connection is not altogether surprising, given the ubiquitous use of both in green-related marketing.

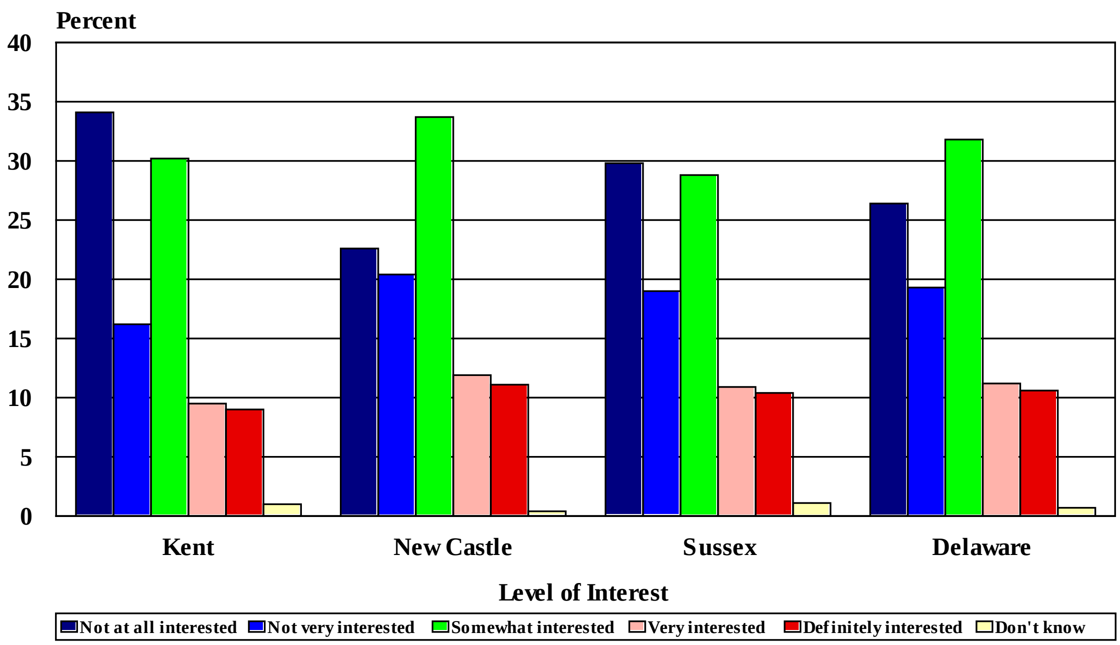
The next section deals with energy audits, where additional aspects of energy-related perceptions and behavior are examined.

Energy Audits

Perhaps one of the most systematic ways of making a home more energy efficient is to undertake a professional energy audit. A properly trained energy auditor can diagnose sources of wasted energy and recommend the most productive and cost effective methods of improving a home's energy efficiency. This section deals explicitly with homeowner opinions about energy audits as well as more specific questions concerning different types of home improvement projects that energy auditors are trained to inspect.

Figure 4 - 1 reports how interested homeowners are in having an energy audit performed for their house.

Figure 4 - 1 Interest in a Professional Energy Audit, by County



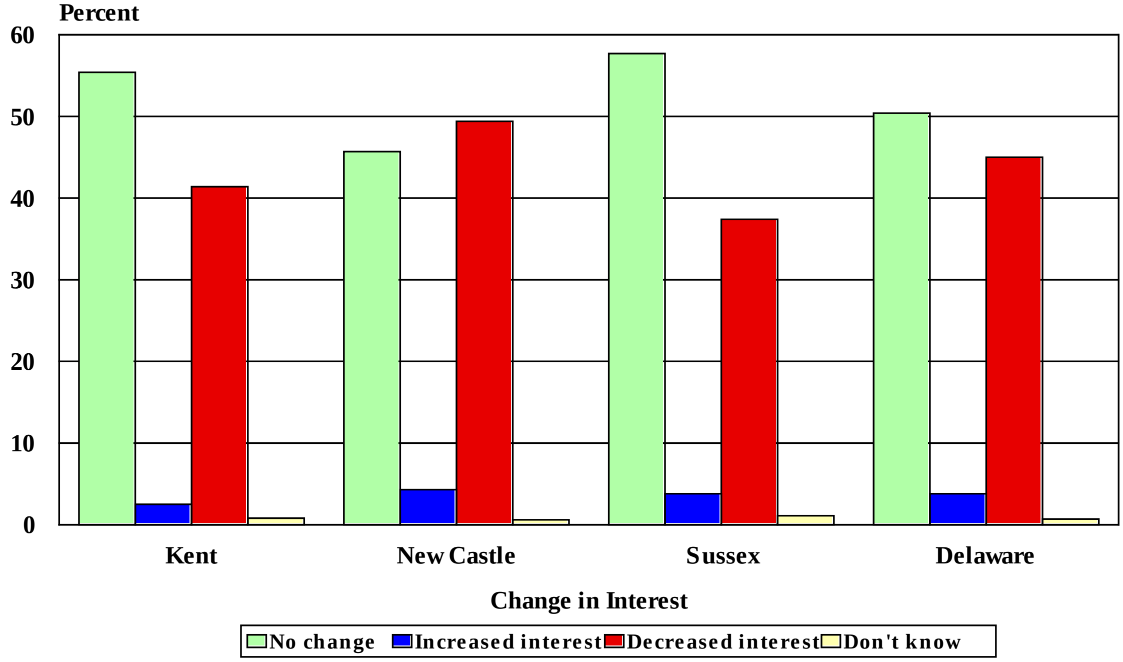
Source: Center for Applied Demography & Survey Research, University of Delaware

The figure shows that slightly more than half of Delaware's homeowners (53.6%) express some interest in the idea of a professional energy audit, and almost 22% have a high degree of interest in an audit. Although not statistically significant, New Castle County homeowners may be slightly more amenable to the concept of an energy audit.

As discussed earlier, when homeowners decide whether to invest in an energy efficient improvement, they are undoubtedly sensitive to the economic factors. A credible energy auditor will have to be aware of those factors when giving advice to homeowners, but homeowners also risk an unethical energy auditor trying to sell unnecessary services.

Similar to an automotive mechanic, most homeowners can never be sure if an energy auditor is behaving ethically, so reputation is likely to play a major role in the homeowner's interest in having an energy audit. The small number of egregious examples in Delaware's Weatherization Assistance Program discovered by a 2010 federal audit poses a direct threat to the homeowner perceptions. Of course, an energy audit's cost and the expected value of the information revealed is another important factor.

Figure 4 - 2 Interest in Professional Energy Audit at Cost $200-$600, by County

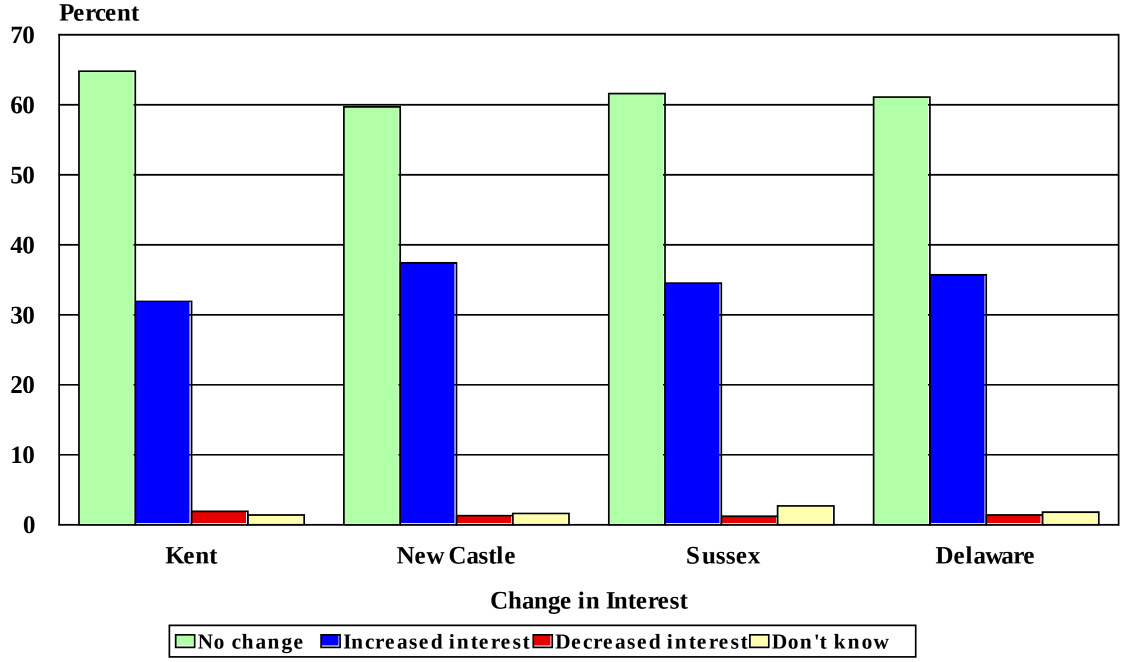


Source: Center for Applied Demography & Survey Research, University of Delaware

To evaluate the impact of setting a price in the respondents mind, respondents were given a probable range of energy audit costs and again asked their interest. Shown in Figure 4 - 2, the results are somewhat predictable. Economics and common sense both tell us that consumer interest tends to fall as price increases. On average, more than 60% of those that had previously expressed some level of interest had lost interest. [6] Even those who previously had been in the *Not very interested* category became less interested. Price makes a difference, and this simple example indicates how economic reality can often jar perceptions.

[6] The fact that a small number of homeowners' interest actually increased suggests that they may have expected an energy audit to have an even higher cost.

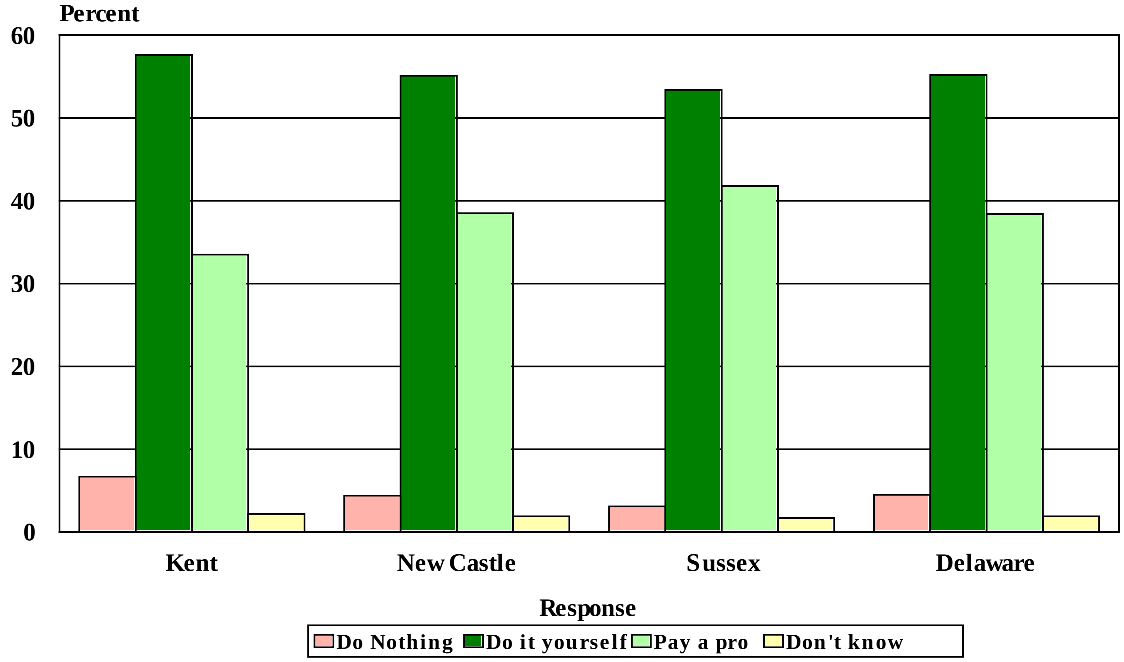
Figure 4 - 3 Interest in Professional Energy Audit with 20% Rebate, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

A follow-up question was posed to homeowners that suggested a 20% rebate of the audit cost could be obtained. As expected, this encouraged some homeowners to react more positively to the prospect of an energy audit. Approximately half of those homeowners who were initially most receptive to energy audit remained interested after the subsequent two questions regarding the price and rebate. Ultimately, the data suggests that approximately 39,000 homeowners are in favor of an energy audit if a 20% rebate was included.

Figure 4 - 4 Homeowner Response to Insufficient or Damaged Insulation, by County

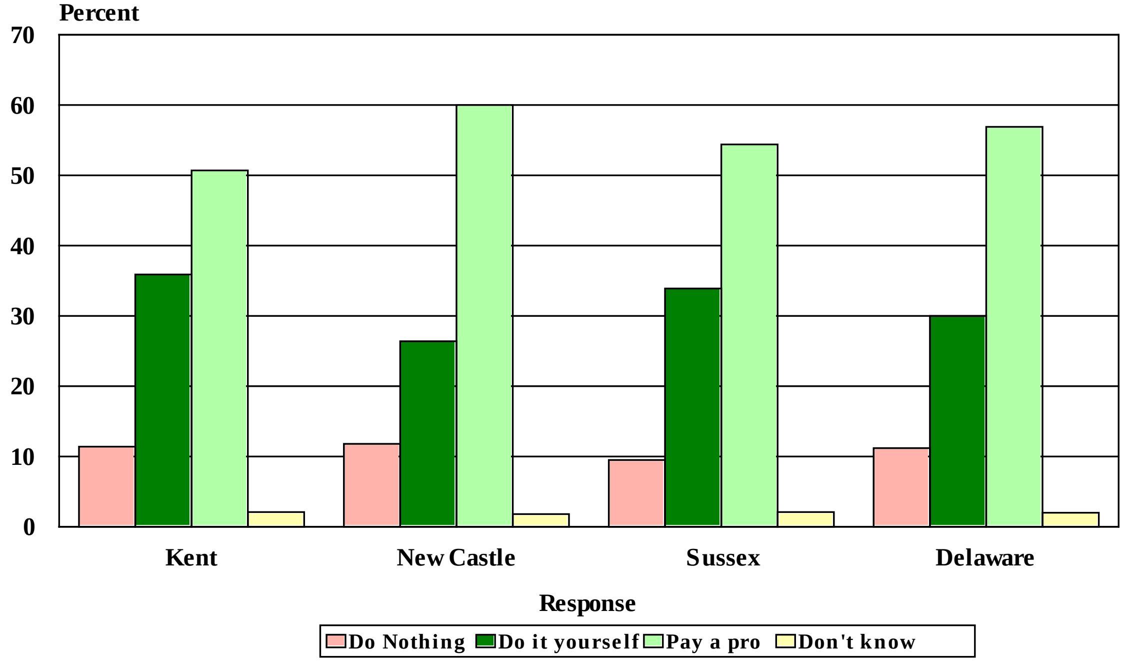


Source: Center for Applied Demography & Survey Research, University of Delaware

An energy audit systematically checks a home's equipment, envelope, and behavior to verify sources of wasted energy. The repairs or improvements can be accomplished in a number of ways. If the job is simple and straightforward, many homeowners will make a trip to a hardware store for materials and supply their own sweat equity. These do-it-yourself (DIY) homeowners will have a limited impact on the labor demand, primarily stimulating jobs in the retail sector. If the project is too complicated, however, then a professional contractor may be employed stimulating demand for the construction sector.

Figure 4 - 4 shows the split between the DIY homeowners and those that hire a professional to repair wet or missing insulation. The figure indicates that most homeowners say that they would try to do insulation home repair projects on their own. A somewhat more difficult task or at least one that the DIY group would have less experience in undertaking is shown in Figure 4 - 5.

Figure 4 - 5 Homeowner Response to Inefficient Windows, by County

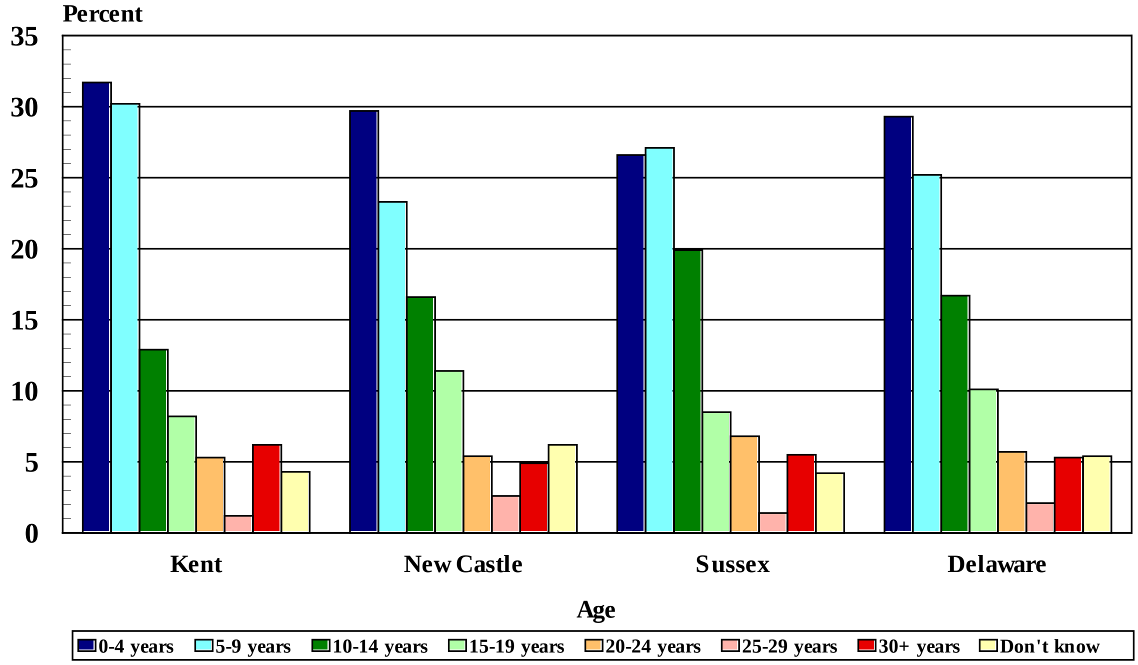


Source: Center for Applied Demography & Survey Research, University of Delaware

Figure 4 - 5 reports the results of a question that asked whether the homeowner would attempt to fix drafty windows with cracked frames on their own. In this scenario, the share of DIY homeowners falls dramatically to 30%. This indicates that homeowners will try to save money where possible, but are hesitant to perform projects requiring greater degrees of skill.

While their numbers are small, some homeowners also said that they would probably do nothing in response to inefficient windows. In fact, there are effectively twice as many homeowners who would not do anything to fix their windows as there are homeowners that would fix their insulation. Presumably the cost of executing this task is substantially higher, and the energy efficiency gains may be perceived to be insufficient to warrant replacing an otherwise serviceable window.

Figure 4 - 6 Age of Home Heating System, by County

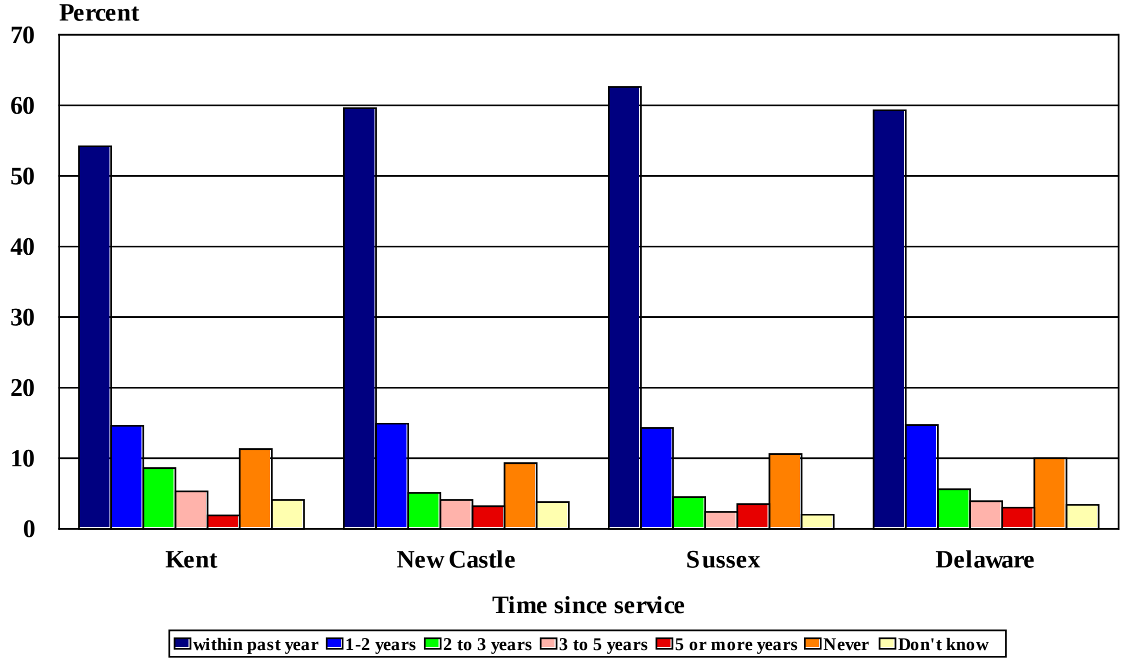


Source: Center for Applied Demography & Survey Research, University of Delaware

Another area which will draw the attention of the energy auditor is the home's heating system, a major consumer of energy. One of the most important determinants of the energy efficiency of the home's heating system is the age of the equipment. Older systems will likely be less efficient than a replacement, because newer technology is generally more energy efficient than older technology. Newer technology will also not have had as much wear and tear. Of course, the make, model, types, use, and service history will be important factors as well. The age distribution is shown in Figure 4 - 6.

For the state as a whole, nearly 55% of the heating systems are less than 10 years old. Because new construction comes with new heating systems and older heating equipment gets replaced when it fails to work properly or becomes too expensive to repair, the graph naturally slopes down from left to right. Only 12% of the current stock exceeds 19 years of age.

Figure 4 - 7 Elapsed Time since heating System Service, by County

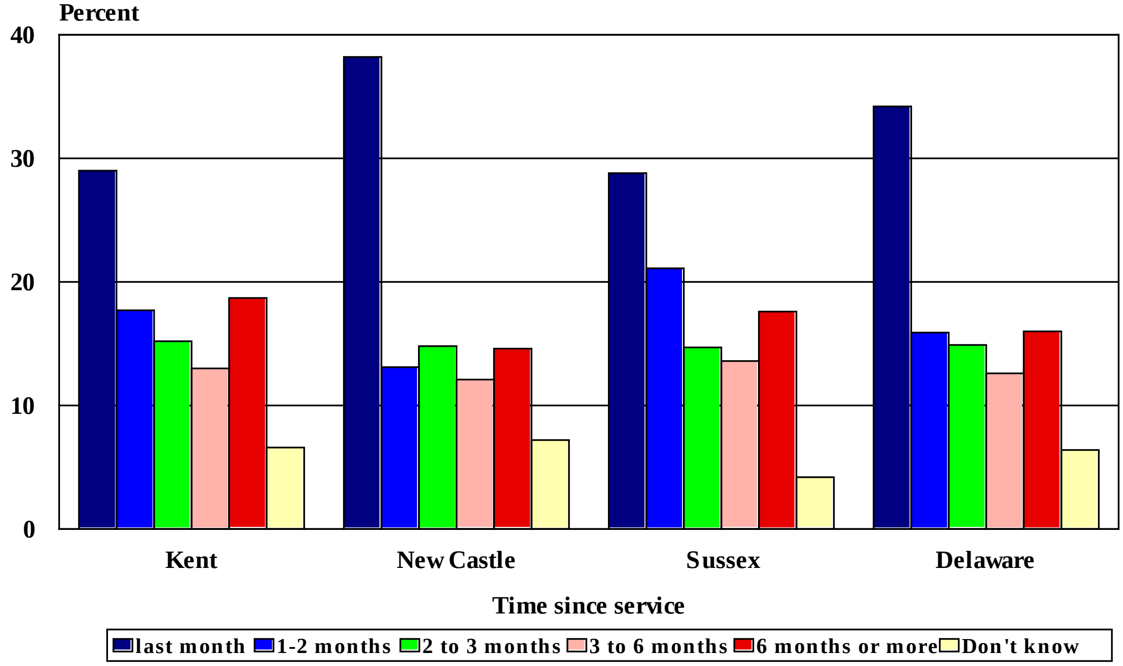


Source: Center for Applied Demography & Survey Research, University of Delaware

The age distribution of heating equipment is similar across counties, but differences that exist are likely due to historical patterns of construction and migration. This is particularly noticeable in Kent County where growth accelerated in the last 7-8 years.

Factors other than age also heavily influence the energy consumption of a heating system. Maintenance is one such critical area, as poorly maintained equipment is quite wasteful of energy. Figure 4 - 7 shows how long ago homeowners reported that their heating system was last serviced. Nearly 60% of homeowners reported that their heating systems had been serviced at least once within the last year. Servicing heating equipment may require a professional, and the amount and type of service will depend upon the type of heating system. Of course, not all maintenance requires a professional.

Figure 4 - 8 Elapsed Time since Heating System Air Filter Serviced, by County

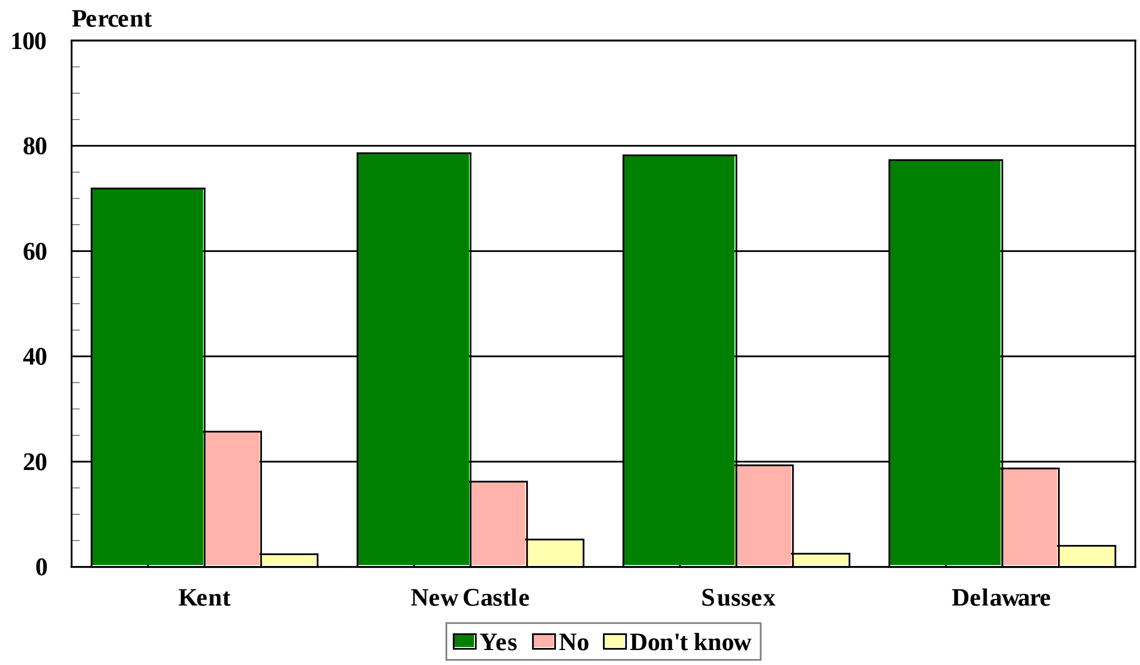


Source: Center for Applied Demography & Survey Research, University of Delaware

Most heating systems have air filters. Some or all of those filters are subjects for routine replacement. A dirty and or clogged filter is not only bad for household health, but it has a major impact on the system's energy efficiency. The heating system documentation usually identifies the general location of the filter(s), the frequency of maintenance, and the expertise required to accomplish the cleaning task. Typically though, air filters are expected to be replaced at least every three months.

Homeowner's were asked about the last time their air filter was replaced on their heating system (see Figure 4 - 8). Roughly two thirds of Delaware's homeowners serviced their air filter within the last three months, implying that a third of Delaware's population can achieve fairly substantial energy efficiency gains at minimal costs. This is very similar to the questions related to programmable thermostats.

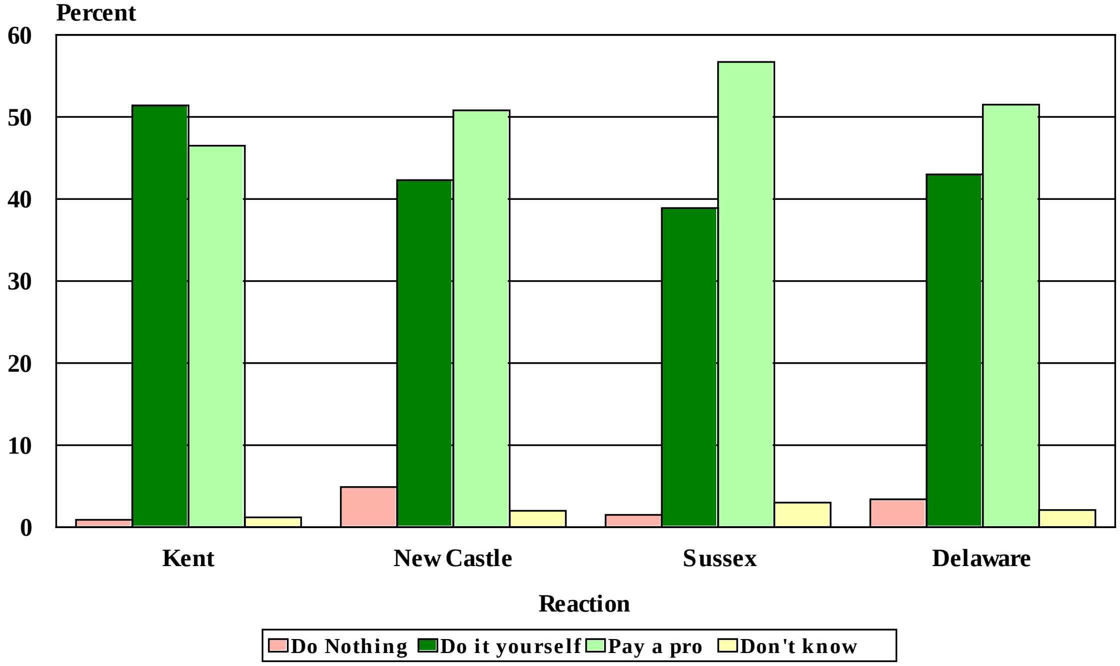
Figure 4 - 9 Home Heating System is Forced Air, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

Air ducts are another factor that can influence the efficiency of both the heating and cooling systems, so we asked homeowners if their heating system used forced-air. Their answers are shown in Figure 4 - 9. Nearly 80% of the state's homeowners have heating systems which require air ducts. Air ducts are a common source of wasted energy that is often checked in an audit, since holes in the sheet metal or the seams will divert hot (or cold) air away from where it is needed.

Figure 4 - 10 Homeowner Reaction to Leaking Air Ducts, by County

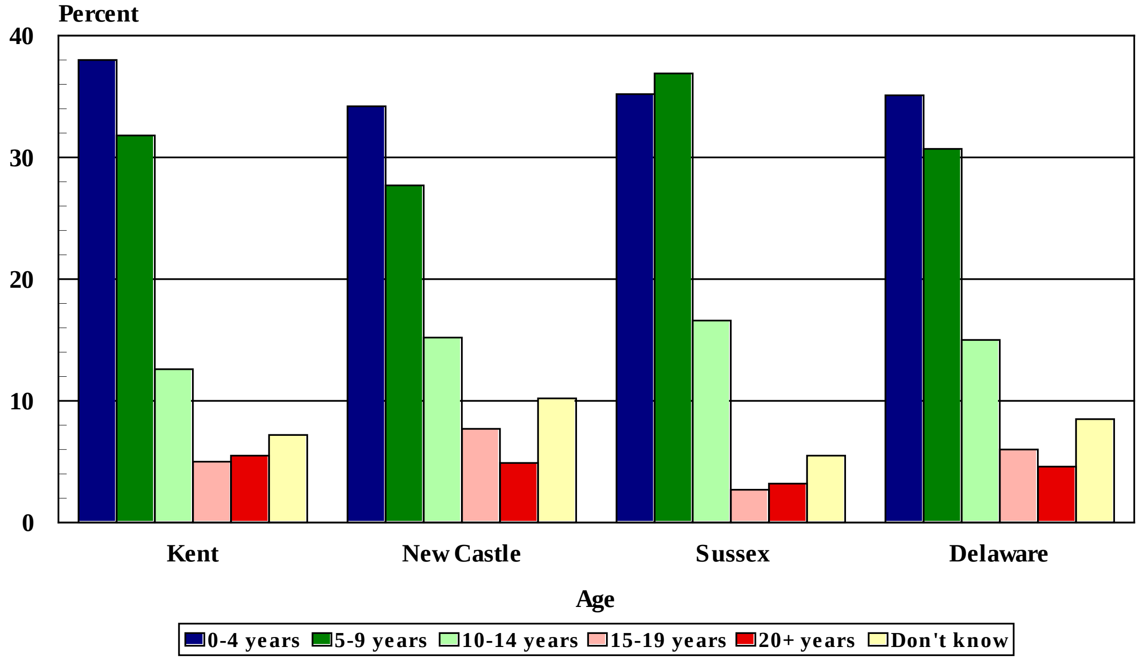


Source: Center for Applied Demography & Survey Research, University of Delaware

Leaky air ducts are often easily corrected with nothing more than special tape, and so is well within the capabilities of a knowledgeable and motivated DIY homeowner. Figure 4 - 10 indicates that just over half of Delaware's homeowners said they would opt for a professional to properly seal and insulate leaky air ducts. More than 40% stated that they would attempt the work themselves.

Credible sources indicate that leaky air ducts lowers heating and cooling efficiently by up to 20% in the typical house (ENERGY STAR, 2011 [2]) and that these heating and cooling systems typically consume 46% of the monthly energy costs (ENERGY STAR, 2011 [1]). Given the prevalence of these systems and the relatively cheap means with which energy efficiency can be achieved, the potential for saving energy is quite significant.

Figure 4 - 11 Age of Water Heater, by County

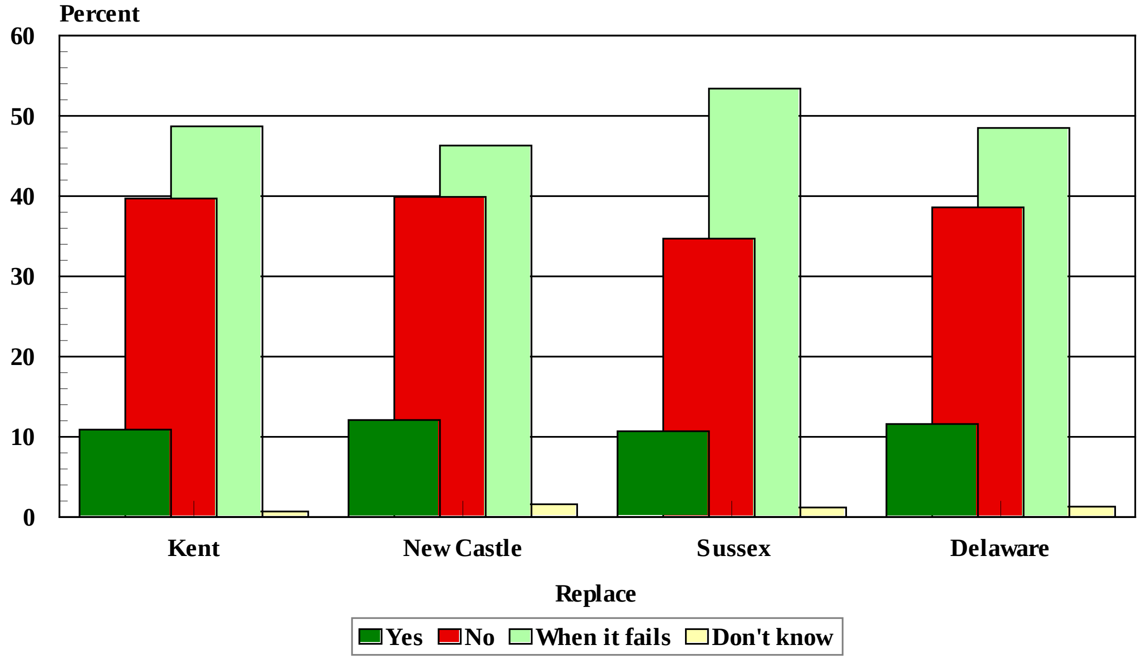


Source: Center for Applied Demography & Survey Research, University of Delaware

Another major target for the energy auditor is the home's water heater. The water heater, like the heating system, has a replacement cycle typically in excess of 10 years. For that reason, the age distribution of water heaters is skewed toward the earlier age groups (see Figure 4 - 11), and the share of water heaters in the older age groups drops rapidly after nine years. This pattern follows for all three counties, and the distributions are likely affected by historical differences in housing development.

Homeowners were also asked if they would be interested in replacing their operating water heater with a new, more energy efficient water heater (see Figure 4 - 12). Only 10% of the respondents said they would, nearly 40% said they would not, and almost 50% said they would only when the equipment failed.

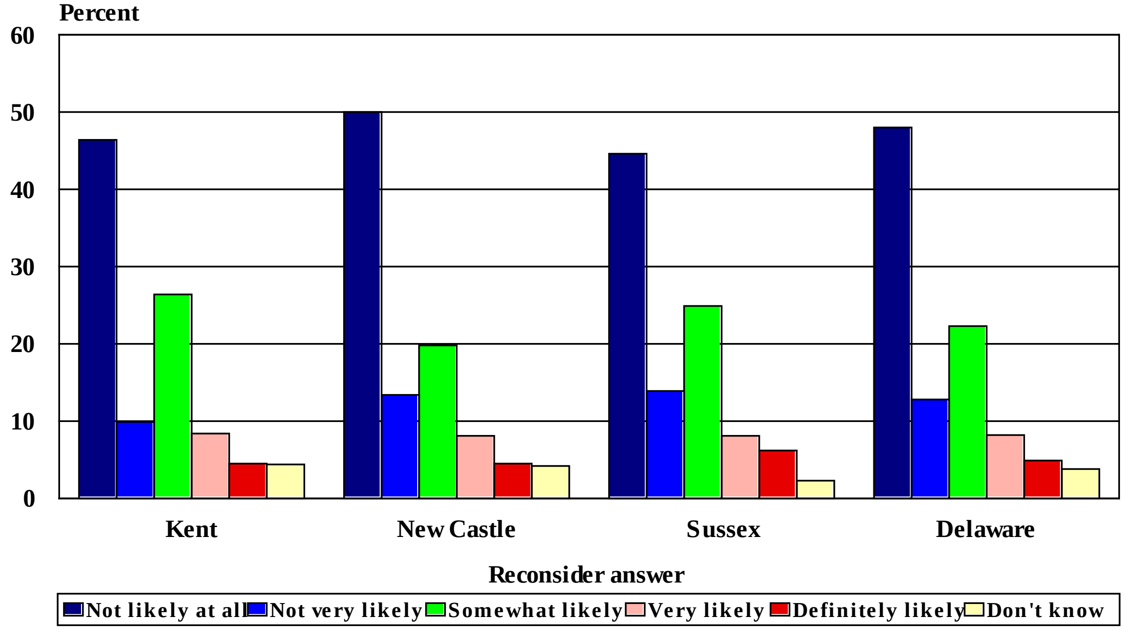
Figure 4 - 12 Homeowner's Response to Water Heater Replacement, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

The average water heater age for homeowners who were willing to replace their water heater for an energy efficient one was 10.6 years. For homeowners who were definitely not willing, the average equipment's age was 5.2 years. For homeowners who would only replace a water heater if it fails, the average age was 7.4 years. The average age was statistically different between each group, and indicates that demographic factors of the equipment seem most likely to explain household patterns of investing in energy efficiency.

Figure 4 - 13 Replace Water Heater with $200 Rebate, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

Figure 4 - 13 indicates whether the households would reconsider their answers if a $200 rebate were offered to upgrade an energy efficient water heater. The rebate may be of interest to a minority of about 12% of Delaware homeowners. The reason probably comes down to economic factors. Replacing an operating water heater is unlikely to compensate the homeowner with reduced energy costs enough to offset the additional upfront costs. Those that could be convinced are probably more likely to need a new water heater in the first place. The average water heater age of homeowners who would definitely not replace it even with a rebate is 5 years. This is significantly lower than the age of water heaters in other groups.

This behavior implies three important facts about energy efficient durable equipment. First, programs that offer rebates for energy efficient water heaters will not likely spur much in the way of *new* demand. Instead, jobs that would have existed installing a less energy efficient water heater will be replaced with a job installing a more energy-efficient water heater.

Second, homeowners most affected by rebate programs are likely to replace the water heater in the near future. This effectively shifts demand for durable equipment from the future to the present. In the short run, this means that a surge of demand will be counterbalanced with a dearth of demand once the rebate program ends.

The third important implication is that the decision of whether to adopt energy efficient appliances today will impact energy consumption for at least a decade, if not two or more. Thus, rebate programs for energy efficient appliances should be properly viewed by their ability to lower energy costs and improve efficiency over the long run, not necessarily for their effects on the labor market.

One thing is clear from this discussion about energy audits and home improvements, homeowners can control many critical energy-saving areas on their own. Good maintenance in accordance with equipment design coupled with guidance (e.g. www.energystar.gov) can yield energy saving benefits without significant upfront costs. Relatively simple projects, such as taping seams in ductwork, laying insulation and using a programmable thermostat, can make large improvements cheaply. But just like diet and exercise, many homeowners do not follow such practices. Large economic and environmental gains could be had if homeowners could be convinced to undertake minimal changes.

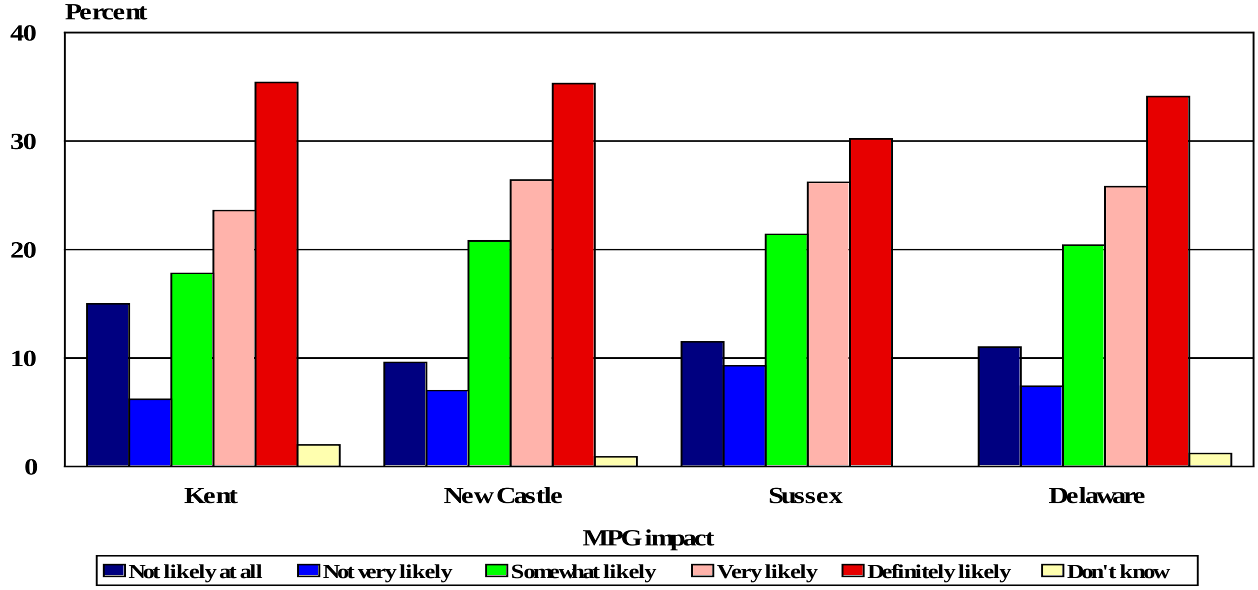
In the next section, the topic of hybrid and electric vehicles is addressed.

Hybrid/Electric Vehicles

Hybrid and electric vehicles are often pointed to as an important strategy to reduce energy use and pollution. Hybrid vehicles have made inroads since oil topped $140 a barrel and gasoline approached $5 per gallon. Electric vehicles are beginning to arrive on the market with great fanfare, but their introduction is too recent to know how strongly they will be adopted, much less how those adoption rates will impact jobs.

There are many things in common with the decision to purchase a ‘green’ car and improve household energy efficiency. Income constraints, for example, will limit some consumers from purchasing a hybrid or an all-electric vehicle. Like energy saving home improvement projects, the decision of driving such a vehicle may come down to how much more expensive these cars are, and how much savings can be had by lower fuel costs. In addition, the decision of whether to purchase a car will likely have long term effects on energy usage, though not quite as long as heating systems or water heaters. Finally, any environmental benefits gained by reducing pollution are not easily internalized by the consumer.

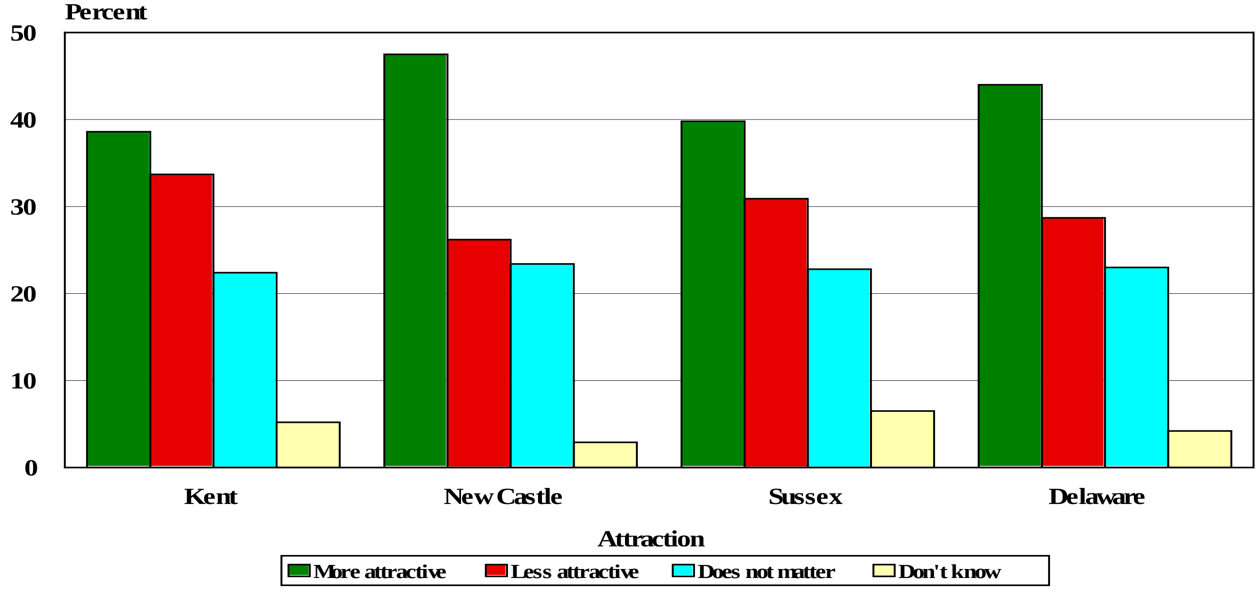
Figure 5 - 1 Miles per Gallon Affects Next Car Purchase, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

The first question in this section asked homeowners how important fuel economy will likely be when purchasing their next vehicle. The results, shown in Figure 5 - 1, indicate that 60% of Delaware homeowners are concerned with the fuel efficiency of a vehicle. Almost 20% of homeowners claim not to consider the issue at all. Income does not appear to be strongly related to the answers to this question. However, only 21% of persons who do not consider energy efficiency to be a worthwhile goal do consider fuel economy to be important. In contrast, 66% of those who believe that energy efficiency is a worthwhile goal also consider MPG to be important.

Figure 5 - 2 Attractiveness of Cars with Hybrid Engines, by County



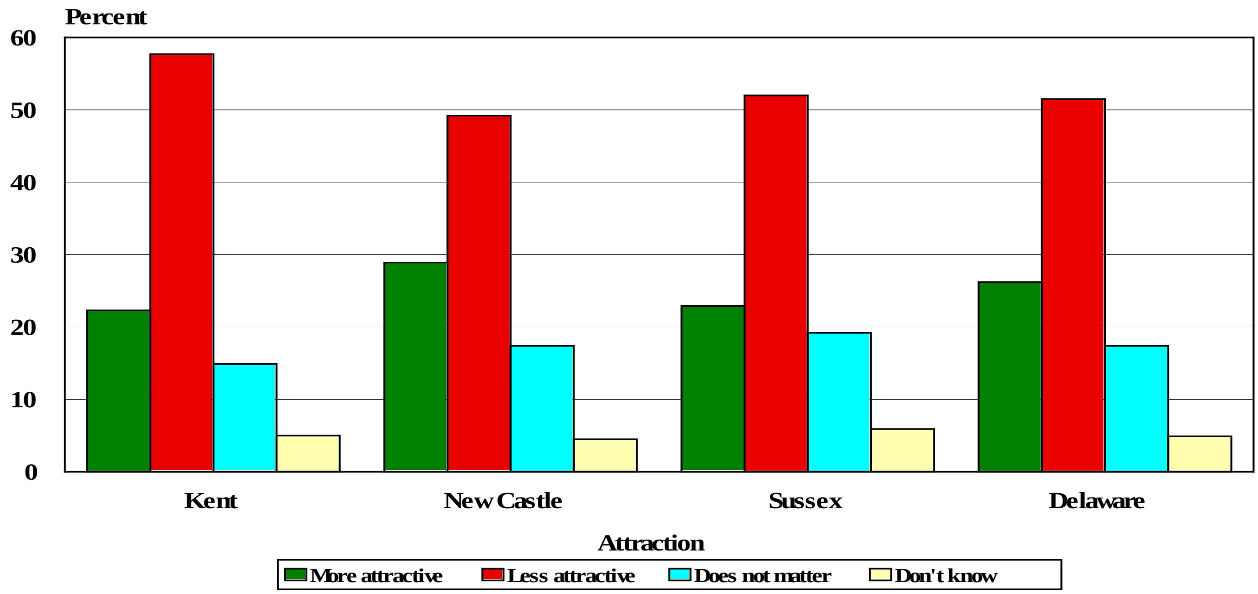
Source: Center for Applied Demography & Survey Research, University of Delaware

The second question in the sequence asked the respondent if the fact that a vehicle had a hybrid engine made the car more or less attractive as a potential purchase. The results are found in Figure 5 - 2. Approximately 43% of the homeowners felt that a vehicle's hybrid engine made it a more attractive option, and 29% of homeowners believed that a hybrid engine made the vehicle less attractive. More than 20% said that a hybrid engine did not matter.

As expected, 74% of those who found the vehicle more attractive also said that they would strongly consider fuel efficiency when purchasing their next a vehicle. For those that found the hybrid engine unattractive, only 43% considered fuel efficiency to be an influential factor. For those that said they were indifferent on the hybrid engine, 54% said that they would consider fuel efficiency when purchasing their next vehicle.

These answers likely reflect that perceptions of hybrid engines have become mainstream. Next we asked homeowners about the perceived attractiveness of 100% electric vehicles.

Figure 5 - 3 Attractiveness of Cars Powered by 100% Electric Powered Engines, by County

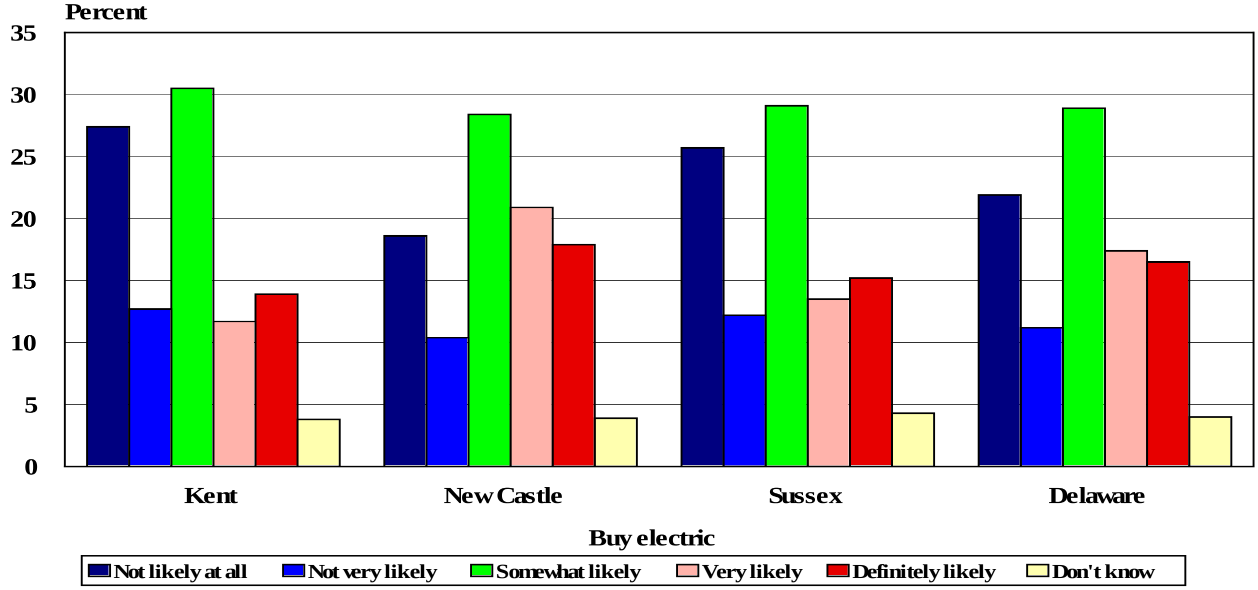


Source: Center for Applied Demography & Survey Research, University of Delaware

Figure 5 - 3 indicates that 28% of respondents believed an all electric car was attractive. More than 50% of respondents felt otherwise, and less than 20% said that did not matter. This is in stark contrast with respect to hybrids, which became highly desirable in 2008 as consumers were painfully reminded of the high price of gasoline. There is marginally more support of electric vehicles in New Castle County than there is in the other two counties. This may reflect the county's increased population density, shorter commutes, and shorter shopping trips.

Unlike the current stock of hybrid cars, electric vehicles still face substantial technological hurdles with respect to battery storage, charging times, and infrastructure. Without resolving these interdependent issues, it is difficult to grow demand and achieve the cost advantages due to economies of scale. Despite these hurdles, a core market undoubtedly exists for these products; 80% of those that were attracted to the hybrid vehicle were also attracted to the electric vehicle.

Figure 5 - 4 Purchase a Competitively Priced 100% Electric-Powered Vehicle, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

The next question sought to understand how much technological issues were behind homeowner perceptions of electric cars. The question asked homeowners how likely they would consider purchasing an electric vehicle if it was *competitively priced*. Approximately 35% of homeowners responded positively to this question, implying an increase of 7 percentage points from the previous question. Interest is certainly a bit higher in New Castle County than in Kent or Sussex, also mirroring the earlier result.

Approximately 95% of those who found electric vehicles attractive supported the goal of reducing energy use. However, those that found these vehicles unattractive also supported the goal 92% of the time. This suggests that the attractiveness of electric vehicles is unrelated to the goal of saving energy. This is not surprising since many additional factors affect the decision to buy a car.

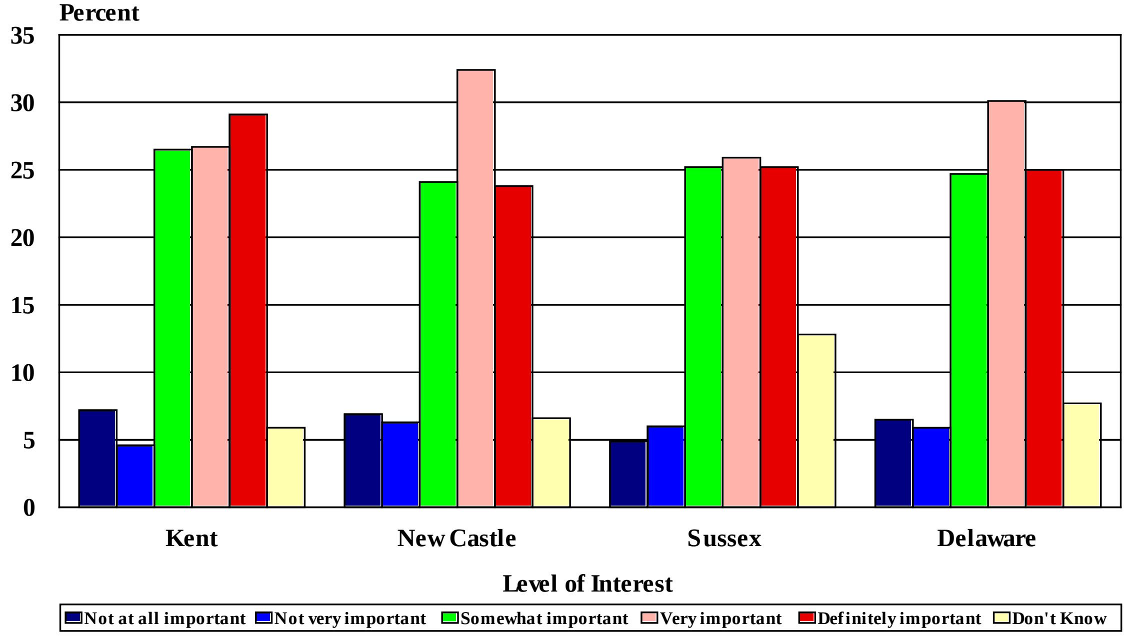
In the next section, the homeowners offer information on their employers.

Employee Perceptions

In an earlier volume of this series, we focused on employers and whether they sold green products and services. We also asked businesses for their general opinions on investing in energy efficiency. Another report focused on energy efficiency in manufacturing exclusively. In this report, we survey homeowners to gather the reaction that employees have regarding their company's response to energy efficiency.

Of course, homeowners and working age members of those households are not a random sample of all employees in Delaware, but they are a substantial portion of the labor-force. The labor-force, which includes Delaware residents who are either employed or unemployed, was 406,000 in 2009. The employees associated with the owner-occupied homes have a weighted total of 322,000 or 79% of the labor-force. An expected 86% of the 322,000 will work for Delaware-based employers.

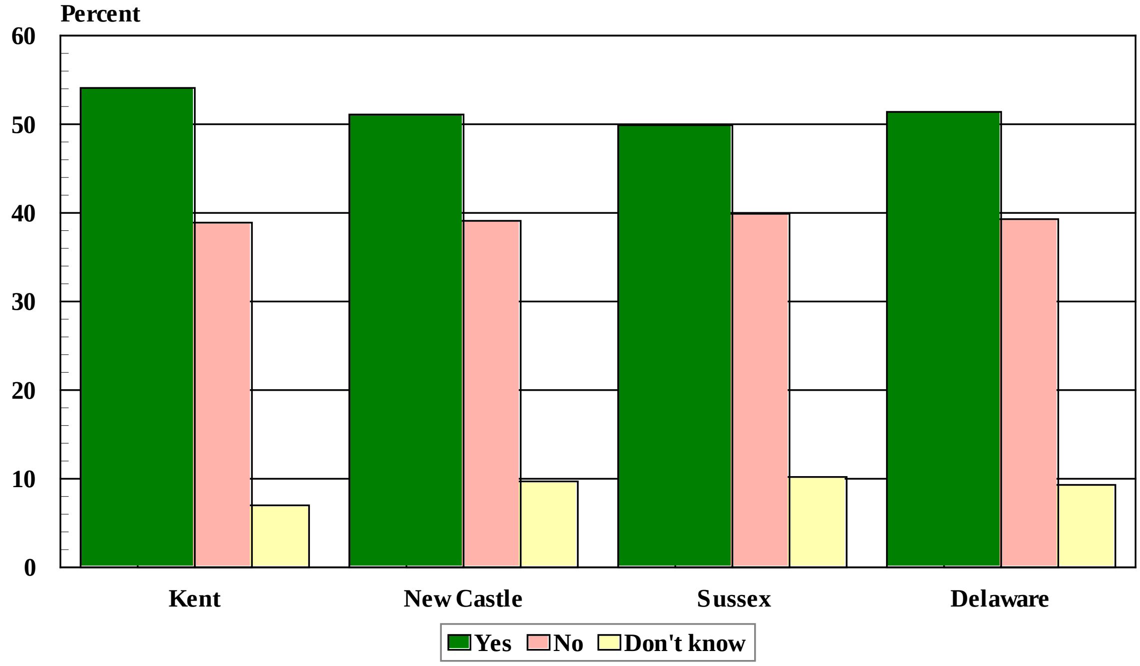
Figure 6 - 1 Importance of Reducing Energy Use to Your Employee, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

The first question we asked of employed respondents was whether their employers thought that reducing energy use was important. Figure 6 - 1 indicates 55% suggested that their employer felt that reducing energy use was very important. This finding corroborates the data obtained in a different survey conducted for this series of reports, in which the average company in Delaware rated the importance of energy costs to be 4.4 out of a maximum scale of 5.

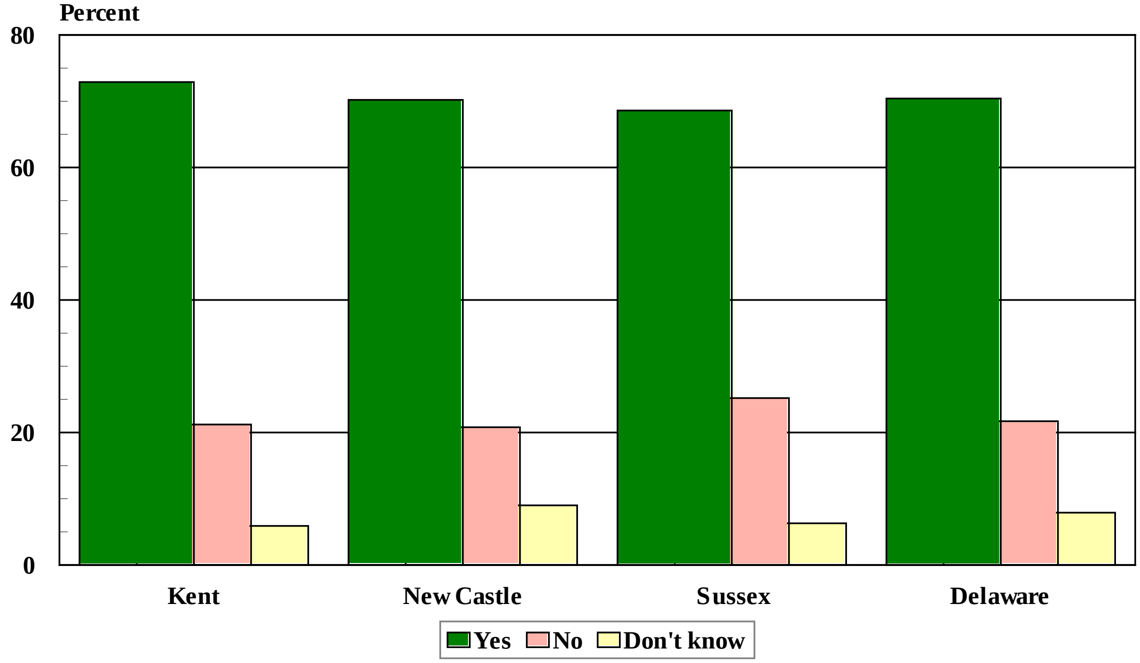
Figure 6 - 2 Method for Employees to Provide Employer Energy Saving Ideas, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

A second factor that indicates the importance of saving energy is whether or not the employer encourages employee participation in ways to save energy. Employed respondents were asked if their employer had an easy method of suggesting energy saving ideas. Figure 6 - 2 indicates that just over half of the respondents believed that such a system was in place. Suggestions provided by employees may be a good way for businesses to find ways of reducing energy consumption.

Figure 6 - 3 Employer is Currently Trying to Save Energy or Reduce Pollution, by County

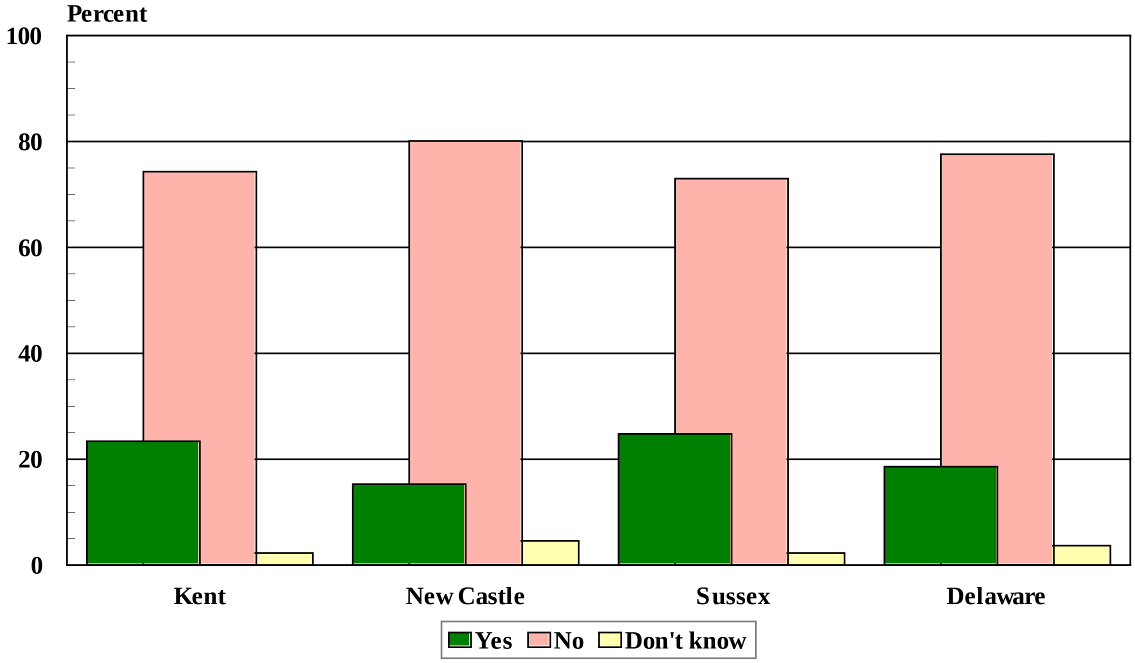


Source: Center for Applied Demography & Survey Research, University of Delaware

Having established that employers think reducing energy use is important, at least as perceived by their employees, the next issue is whether those businesses have actually undertaken projects, processes, or procedures to do conserve energy. Figure 6 - 3 indicates that more than 70% of the employees questioned believe that their employer is doing something to conserve energy.

As a follow up to this question, respondents were asked whether those actions required any job training. Less than 20% of the employees questioned indicated that job training was required (see Figure 6 - 4). This implies that there may be many such energy-saving activities a business can undertake that does not require special certifications or skills beyond those found in a typical workforce.

Figure 6 - 4 Job Training Required to Save Energy or Reduce Pollution, by County

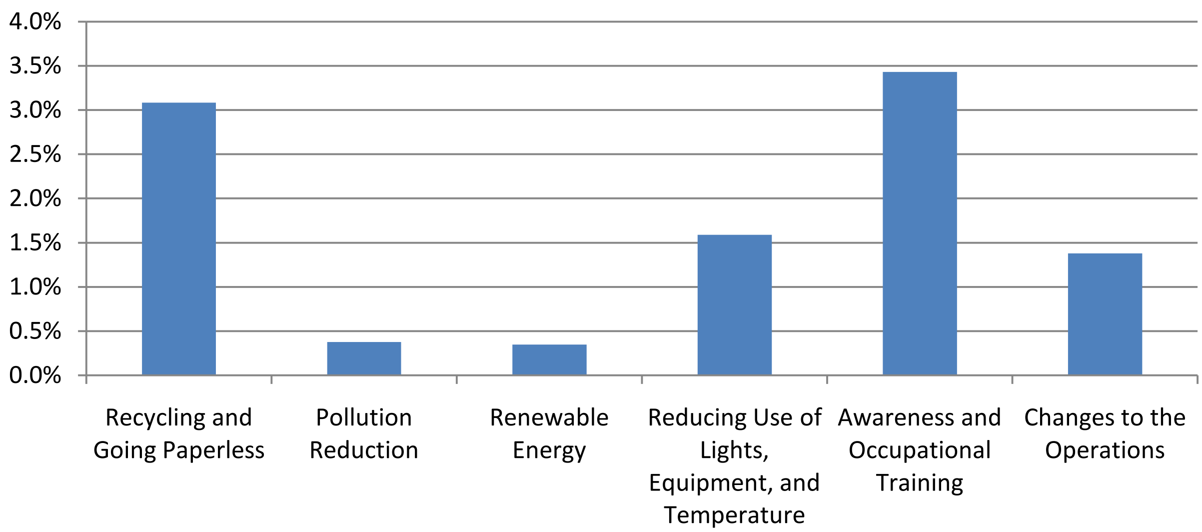


Source: Center for Applied Demography & Survey Research, University of Delaware

This is an important result, because the common working definition of green jobs classifies jobs into two separate categories. Green jobs falling under the *output approach* refers to those employees who work for companies that make green goods and services. Green jobs falling under the *process approach* refers to those employees whose work activities are directly conserve energy, reduce pollution, use renewable energy, or conserve natural resources for their employer. The survey responses indicate that green jobs falling under the process approach implicitly competes with other ways a company can save energy or cut pollution.

Of those respondents who answered that the energy-saving activities required job training, a follow up question asked them to describe what that training entailed. Because the nature of the question was free response, these responses were manually categorized and the most common answers are reported in Figure 6 - 5.

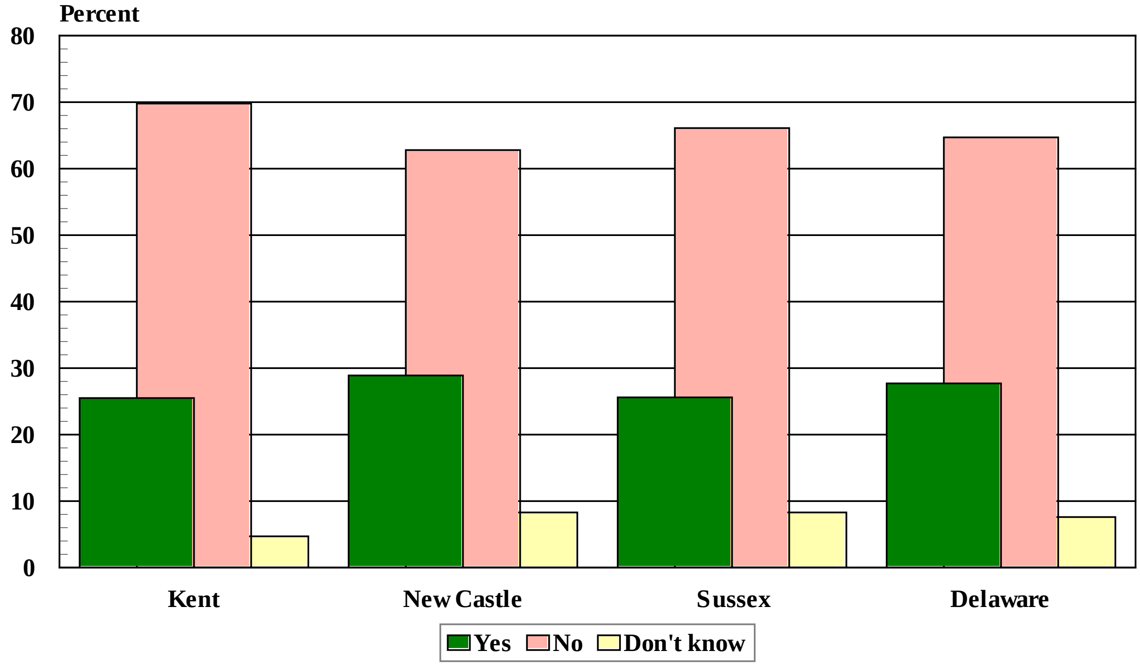
Figure 6 - 5 Percentage of Employed Persons Claiming to Have Received Training on Specialized Green Activities



Source: Center for Applied Demography & Survey Research, University of Delaware

Approximately 3% of employees responded that they received training in recycling and how to go paperless as a direct result of their employer's efforts to go green. Another common response (3.4% of employees) was that the training took the form of general awareness of their occupation's energy use and other green related issues. Approximately 1.6% of employees said that they received training on how to turn off lights and equipment when not in use. Only 1.4% indicated that operations changed enough to require new training. The results suggest that most employees receiving green training are being directed to alter behavior, instead of upgrading skills.

Figure 6 - 6 Employee has Ideas to Help Employers Save Energy or Reduce Pollution, by County

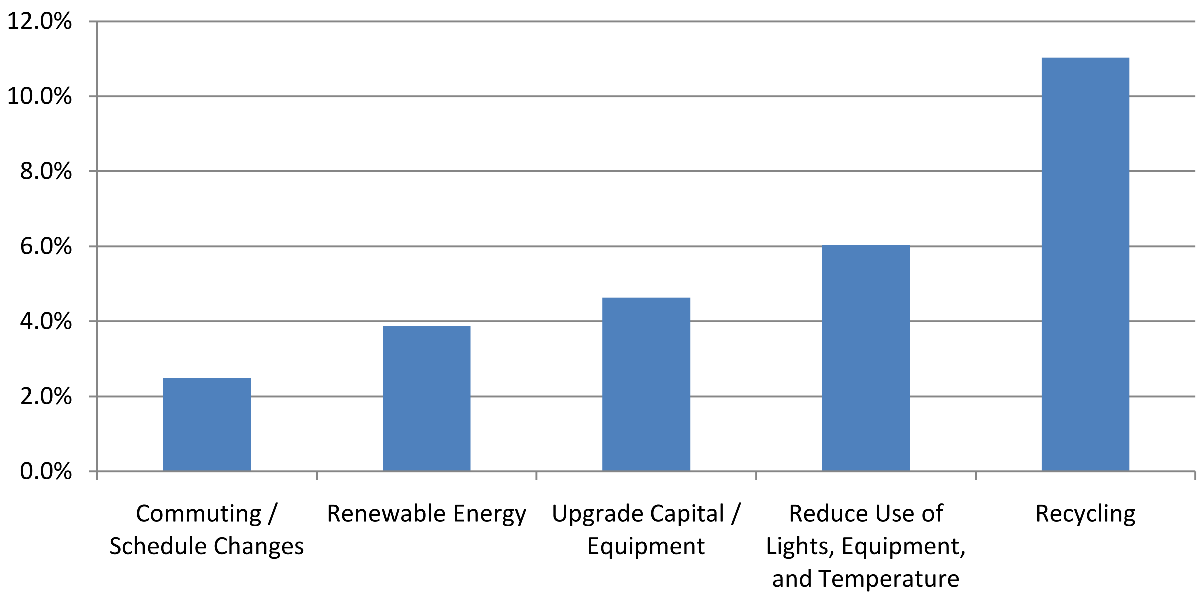


Source: Center for Applied Demography & Survey Research, University of Delaware

Employed respondents were then questioned if they personally could think of any additional other energy-saving activities that their employer had not yet initiated. As shown in Figure 6 - 6, more than a quarter of employees reported that they did have ideas. A follow-up question asked those employees to describe what type of activities they had in mind (see Figure 6 - 7) and whether they thought training would be needed to implement such activities (see Figure 6 - 8).

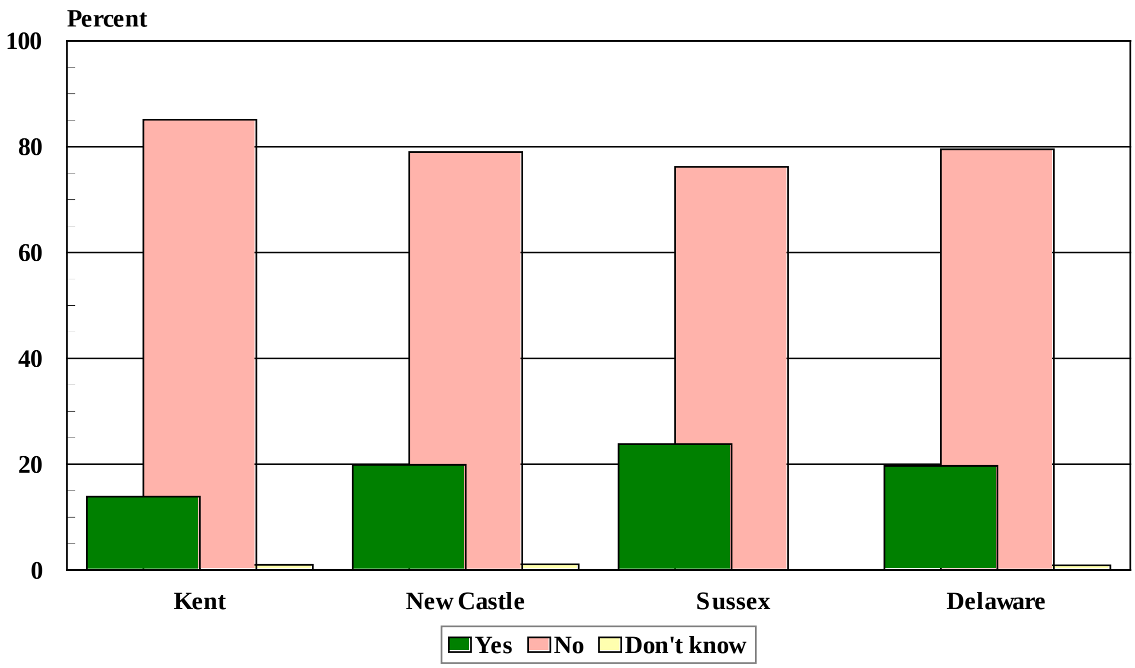
The most common idea was for the employer to recycle more or reduce the amount of paper they used (11%). Nearly 6% of employed persons said that their company could do a better job of turning off equipment when not in use, reduce unnecessary lighting, or improve the climate control in their buildings. In addition, 4.6% said that their company should upgrade equipment, most commonly commercial HVAC systems. Slightly less than 4% of employees said that their company could use renewable energy, and approximately 2.5% of employees said that better scheduling and transportation would help.

Figure 6 - 7 Categorization of Employee Ideas to Help Employers Save Energy or Reduce Pollution



Source: Center for Applied Demography & Survey Research, University of Delaware

Figure 6 - 8 Employee Ideas Require Job Training, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

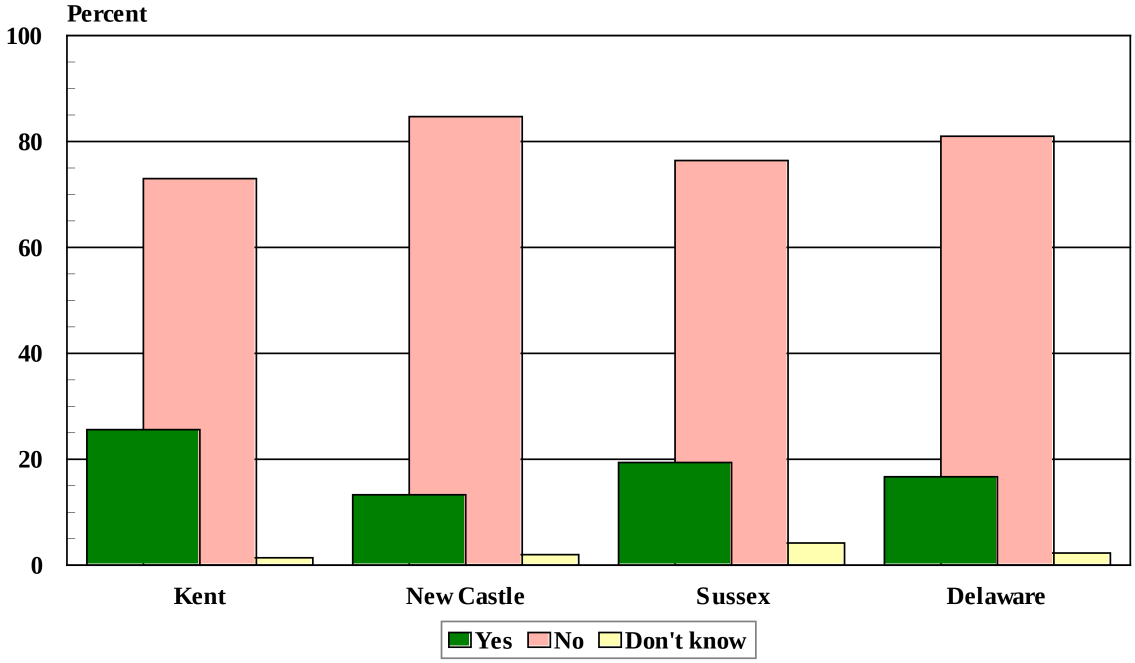
Of those who could think of ways for their employers to save energy, only 20% said that those ideas would require additional job training. From this, we infer that 4% of employees surveyed believe that some type of training could yield environmental benefits in the workplace.

Recommendations where job training was most often cited as appropriate included renewable energy (35%), upgrading capital equipment (29%), and recycling (18%). Respondents did not believe that turning off equipment when not in use or reducing lighting (6%) required much in the way of job training. Similarly, only 2% of those recommending that work schedules be adjusted believed that job training was necessary to implement these changes. Thus, it is doubtful that most environmentally-sensitive ideas coming from employees will require any upgrading of skill sets.

Next, employees were asked whether their job duties had been changed in any way to address environmental concerns. Just over 15% of the respondents indicated that their own jobs had been affected in some way as a result of the energy-saving or pollution reducing activities (see Figure 6 - 9).

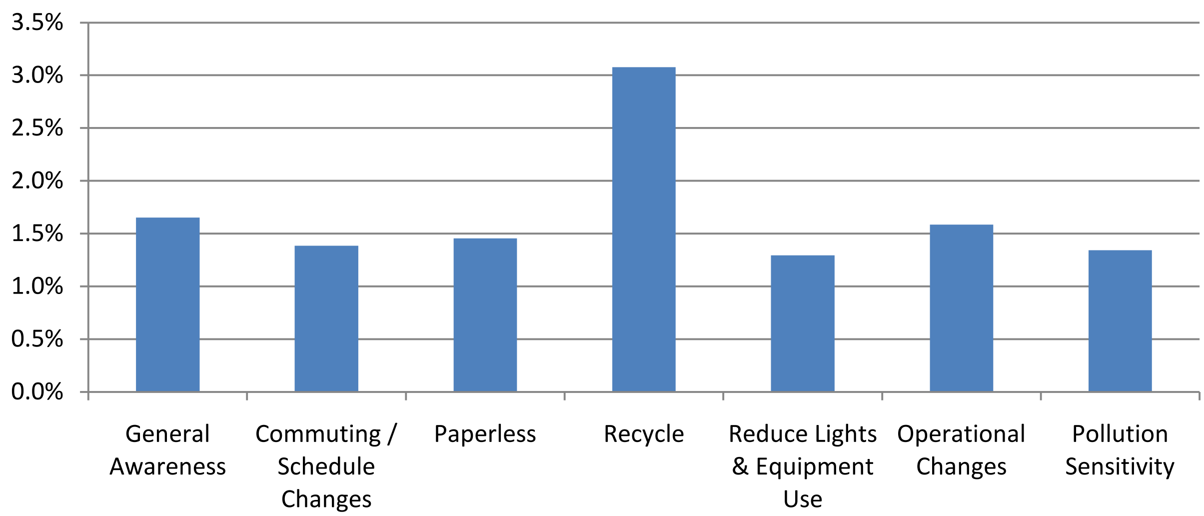
When asked to describe how those job duties have changed, approximately 3% of employees surveyed said that increased recycling was the most common change in job duties. Other categories were mentioned by approximately half as many respondents. For example, approximately 1.5% of respondents indicated that the actual operations of their job had changed. Evaluating these text responses suggests that many of these respondents likely worked directly with industrial processes.

Figure 6 - 9 Changes in Employee's Job to Save Energy or Reduce Pollution, by County



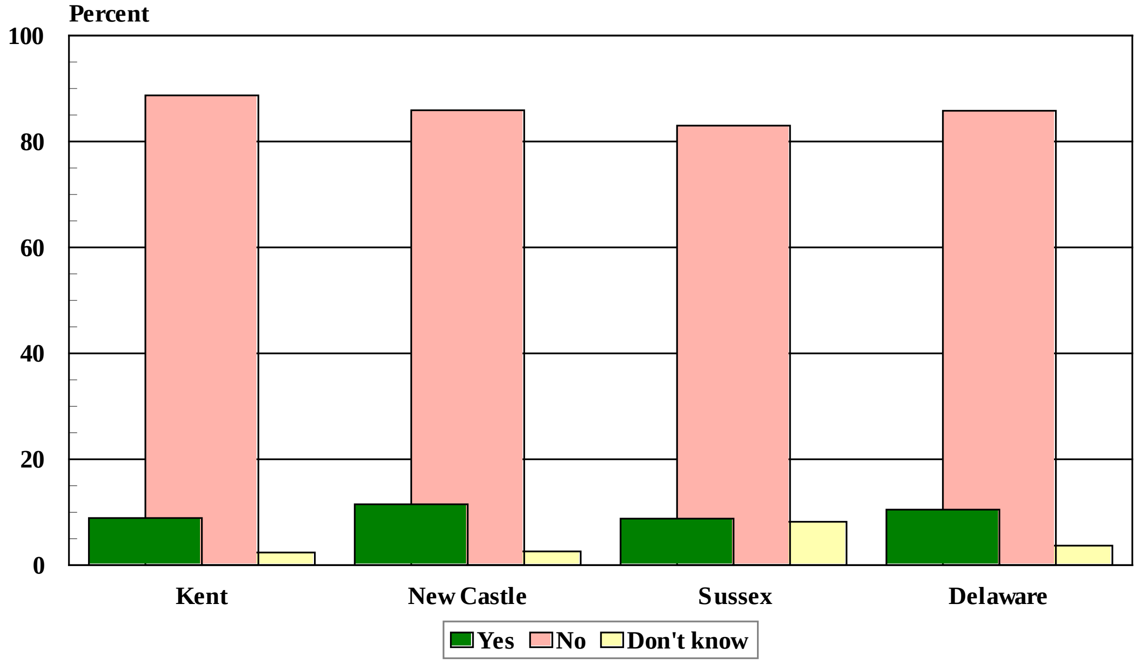
Source: Center for Applied Demography & Survey Research, University of Delaware

Figure 6 - 10 Categorization of Reported Change in Job Duties to Save Energy or Reduce Pollution



Source: Center for Applied Demography & Survey Research, University of Delaware

Figure 6 - 11 New Skills Required to Save Energy or Reduce Pollution, by County



Source: Center for Applied Demography & Survey Research, University of Delaware

The final question in the sequence asked employees whether they could think of any new skills, knowledge, or abilities that would help them save energy or reduce pollution in their jobs. As shown in Figure 6 - 11, about 10% said that they could. However, upon closer inspection, most of these answers related to telecommuting and/or general awareness, was largely repetitive of answers to previous questions, and did not identify any particular workforce skills.

In conclusion, our survey found that employees generally view saving energy and reducing pollution in their workplaces as things that do not require much in the way of new skills. Instead, they view those goals as requiring behavioral changes, such as turning lights off and recycling more. Of course, there is a degree of semantics at play. Some may view such behavioral change to be “skills”. These results do suggest a need for improved supervision.

Next the survey results are used to project future consumer demand and derive labor demand.

Section II – Application

Forecasting Consumer Demand

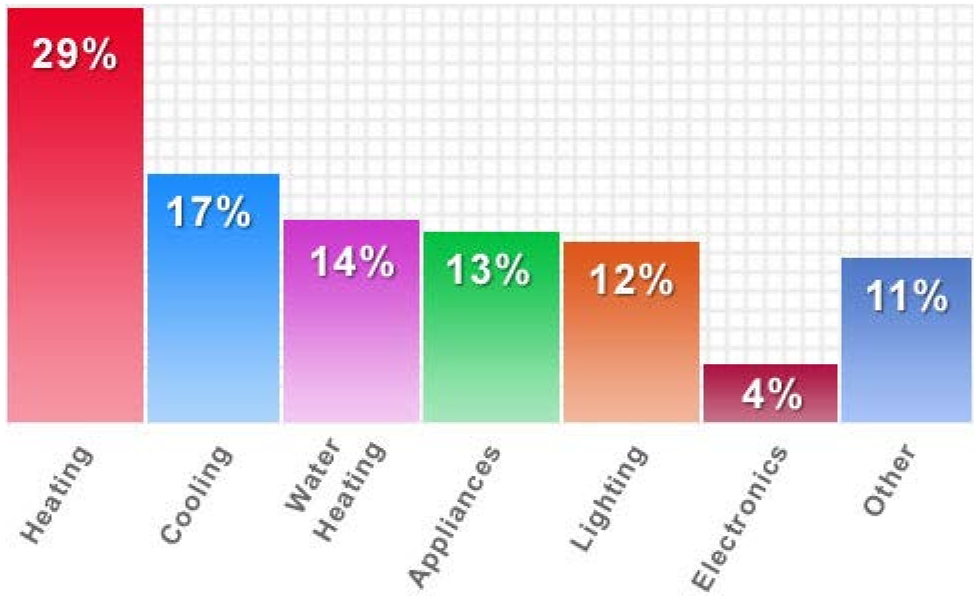
This section estimates the likely future household demand for equipment critical to residential energy use. We focus on the consumer demand for *existing homeowners* and ignore new construction. Projecting patterns of new construction is fraught with predicting uncertain changes in macroeconomic conditions. Existing households, on the other hand, can be reasonably expected to follow historical patterns of behavior, at least as it applies to energy-related residential remodeling projects.

We forecast future demand using two different approaches. The first approach projects the future demand for energy-related services based on the demographic profile of residential equipment. The second approach develops a statistical model of household behavior, and applies the results from our survey to predict future demand. Once we have estimates of consumer demand, we then infer the direct impact on labor requirements using sales to employment ratios.

We make forecasts for six specific types of residential equipment in this section, including insulation, water heaters, air conditioning systems, heating systems, windows and doors, and roofs. Each of these projects is critical to a home's energy performance. In fact, ENERGY STAR.gov (2011 [1]) reports that 29% of energy expenditures are due to heating a home, 17% are due to cooling a home, and 14% are due to water heaters (see Figure 7 - 1). From the perspective of green jobs, when these projects are professionally done, they require skilled labor. Therefore, these six projects are directly relevant to green jobs in the residential energy efficiency sector.[7]

[7] The remaining categories, though important to energy use, are not expected to have a direct or local impact on jobs, except possibly via the retail industry. Light bulbs, televisions, computers, refrigerators, washers, and dryers, for example, are critical to energy consumption, but are not manufactured in Delaware. They are also rarely installed by professional contractors.

Figure 7 - 1 Annual Energy Bill for the Typical Single Home



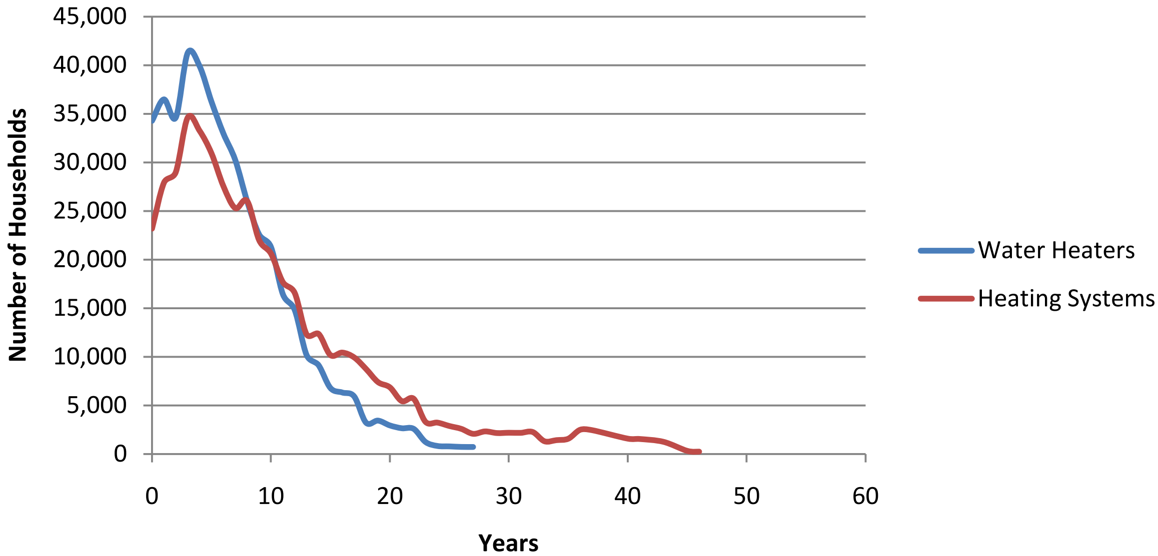
- Source: ENERGY STAR.gov website [1]. Original source: Lawrence Berkeley National Laboratory, 2009.

Moreover, the costs of heating and cooling a home are not entirely determined by the efficiency of the home's air conditioning or heating systems. The envelope to a home is also critical. A drafty house can easily offset the savings of energy-efficient appliances. Therefore, we also focus on the residential demand for insulation, windows and doors, and roofing projects.

Modeling Household Demand: Age Distribution and Ratio Approach

The age of residential equipment is a key component in estimating the future demand, since equipment wears out over time. Because homeowners typically will keep equipment until the end of its useful life, decisions made today will have long term effects on energy use. This also implies that the equipment's age and lifespan can estimate the projected replacement needs. To this end, we use the age distributions of Delaware's housing stock, water heaters, and heating systems to estimate their annual future demand. Then we apply national ratios to estimate what the likely demand will be for the remaining equipment.

Figure 7 - 2 Smoothed Age Distribution of Water Heaters and Heating Systems in Delaware

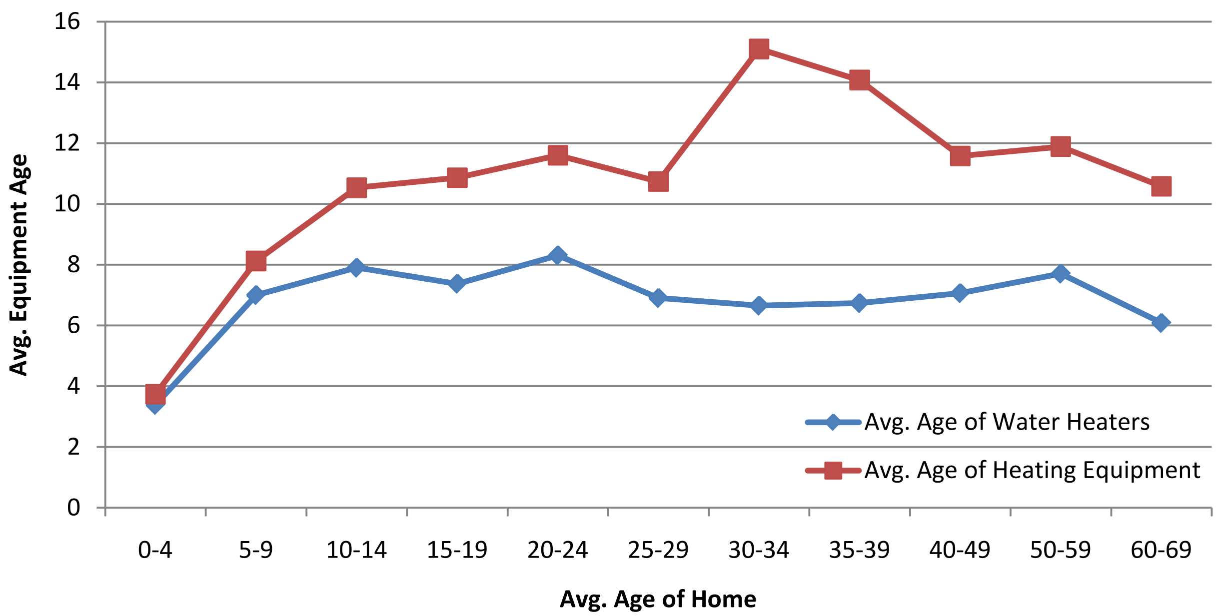


- Source: Center for Applied Demography & Survey Research

Recall that our survey asked households to report the age of their water heaters and heating systems. Figure 7 - 2 displays the 5-year smoothed age profile for each type of equipment. The distributions tell us that most of the equipment in the state is less than 10 years old. Although tails on both distributions reflect a relatively large number of homeowners using older equipment, heating systems have a particularly long tail. These distributions are intuitive, as most equipment will fail and need to be replaced when they reach the end of their useful life, but some equipment will continue to function for many decades.

The figure also indicates that Delaware has a surge of water heaters and heating equipment at about 5 years of age. We suspect this is due to the construction boom ending in 2007, and the fact that new homes usually come with new residential equipment. In Kent County in particular, a large stock of housing was built (see Figure 1 - 1) during this time. This means that the distributions above capture both the effects of equipment failing as well as uneven construction patterns. In order for us to use the age distribution to properly forecast replacement needs, we need to isolate the effects of equipment failure.

Figure 7 - 3 Avg. Age of Water Heaters and Heating Systems in Delaware, by Age of Home



- Source: Center for Applied Demography & Survey Research

Figure 7 - 3 shows the average age of water heaters and heating equipment by the age of the housing stock. Because new homes come with new equipment, the age of new homes and new equipment will be approximately the same. Over time, both equipment and homes get older, but equipment wears out faster and is replaced while the housing unit continues aging. Intuitively, equipment age is related to the age of the home and the rate at which previous equipment failed.

The appendix details how we calculate failure rates for both water heaters and heating systems using the age profiles above. Briefly, we assume that equipment failure rates are the same over time, though they change as equipment ages. For example, a 10 year old water heater in 2000 is assumed to have the same chance of failing as a 10 year old water heater in any other time period. However, a 10 year old water heater in 2000 will be less (or more) likely to fail than a 15 year old water heater today (or any other time period). Under this assumption, we first estimate the failure rate for new equipment (0-4 years), then we estimate the failure rate for slightly older equipment, (5-9 years), then again for slightly older equipment (10-14 years), and so on.

Table 7 - 1 Estimated Age Profile of Water Heaters in Delaware, by County

	Kent	New Castle	Sussex	Estimated 5-yr Failure Rate
0-4 years	34,137	96,994	41,983	4.3%
5-9 years	28,562	78,599	44,075	15.0%
10-14 years	11,328	42,960	19,757	36.2%
15-19 years	4,474	21,903	3,214	57.4%
20+ years	4,905	13,851	3,763	48.4%
Unknown	8,355	31,958	9,367	
Total	91,760	286,265	122,158	

- Source: Center for Applied Demography & Survey Research

Table 7 - 2 Estimated Age Profile of Heating System in Delaware, by County

	Kent	New Castle	Sussex	Estimated 5-yr Failure Rate
0-4 years	29,008	84,980	32,473	0.0%
5-9 years	27,679	66,750	33,140	3.6%
10-14 years	11,815	47,545	24,325	18.9%
15-19 years	7,529	32,505	10,349	35.5%
20-24 years	4,829	15,320	8,279	34.2%
25-29 years	1,122	7,468	1,748	55.8%
30+ years	5,712	13,982	6,715	31.8%
Unknown	4,067	17,714	5,128	
Total	91,760	286,265	122,158	

- Source: Center for Applied Demography & Survey Research

Given the failure rates of each technology and the age distribution of the stock of residential equipment (see Table 7 - 1 and Table 7 - 2), we project what the replacement needs will be for Delaware's existing stock of residential equipment. We further assume that homeowners will replace 95% of the water heaters and heating systems that fail. For example, the survey indicated that 34,137 households in Kent County own a water heater that is less than 5 years old. If 4.3% of these fail within five years, and 95% of those that fail are replaced, then (34,137×0.043×0.95=) 1,399 water heaters will be replaced between 2011 and 2015 (answer differs slightly due to rounding). Table 7 - 3 shows this calculation for each county and equipment group. Then the stock is rolled forward five years, and the process repeats.

Table 7 - 3 Forecasted Water Heater Replacement Needs for Delaware Homeowners, 2011-2021

	2011-2015			2016-2021		
	KNT	NCC	SSX	KNT	NCC	SSX
0-4 years	1,399	3,974	1,720	576	1,978	749
5-9 years	4,075	11,213	6,288	4,670	13,270	5,744
10-14 years	3,893	14,763	6,789	8,415	23,157	12,985
15-19 years	2,440	11,948	1,753	4,056	15,382	7,074
20+ years	2,256	6,370	1,731	2,153	8,019	1,606
Total 5yr Replacement	14,062	48,269	18,281	19,871	61,805	28,158
Annual Replacement	2,812	9,654	3,656	3,974	12,361	5,632

	KNT	NCC	SSX
Adj. Avg. Annual Replacement	3,652	12,248	4,911

- Source: Center for Applied Demography & Survey Research

* 95% replacement rate assumed for failed equipment

Table 7 - 3 shows the estimates that 190,446 water heaters will need to be replaced in Delaware over the next decade, with most of those replacements occurring in New Castle County. However, because 5.4% of Delaware homeowners did not know the age of their water heaters, we adjusted those values upwards by the appropriate proportion in each county. Ultimately, this method predicts that an average of 20,812 water heaters will need to be replaced in Delaware each year over the next decade. Nearly 12,250 units are expected to come from New Castle County, 4,900 from Sussex County, and 3,650 in Kent County.

Similarly, Table 7 - 4 shows the forecasted replacement needs of heating systems. Relative to water heaters, fewer heating systems will need to be replaced. This result owes mainly to the decreased failure rates implied by the age distributions in our survey. Over the next decade, the age distribution approach estimates that 14,533 heating systems will need to be replaced each year. Nearly 8,450 units are expected to come from homeowners in New Castle County, 2,450 from homeowners in Kent County, and 3,650 from Sussex homeowners.

Table 7 - 4 Forecasted Heating System Replacement Needs for Delaware Homeowners, 2011-2021

	2011-2015			2016-2021		
	KNT	NCC	SSX	KNT	NCC	SSX
0-4 years	0	0	0	0	0	0
5-9 years	942	2,273	1,128	988	2,893	1,106
10-14 years	2,126	8,555	4,377	4,811	11,601	5,760
15-19 years	2,542	10,976	3,495	3,272	13,165	6,736
20-24 years	1,569	4,977	2,690	1,620	6,995	2,227
25-29 years	594	3,956	926	1,727	5,479	2,961
30+ years	1,728	4,229	2,031	1,365	4,012	1,665
Total 5yr Replacement	9,502	34,966	14,647	13,782	44,146	20,455
Annual Replacement	1,900	6,993	2,929	2,756	8,829	4,091

	KNT	NCC	SSX
Adj. Avg. Annual Replacement	2,436	8,433	3,664

- Source: Center for Applied Demography & Survey Research

* 95% replacement rate assumed for failed equipment

The remaining four improvements we focus on are air conditioning systems, windows and doors, insulation, and roofs. However, our survey did not ask for the age of these equipment. Instead, we use historical ratios of various construction projects to estimate the approximate demand for these home improvement projects. Every two years, the Joint Center for Housing Studies (JCHS) of Harvard University assesses the home remodeling market and tabulates national remodeling statistics from the American Housing Survey. Our ratios are derived from JCHS tabulations (JCHS, 2009; JCHS 2011).

Table 7 - 5 Estimated Number of US Homeowners ('000s) Performing a Remodeling Project and Implied Ratios

	Total Projects		Implied Ratios	
	2007	2009	Water Heaters	Heating System
Water Heaters	3,152	3,259	1.00	1.43
Air Conditioning	2,096	1,957	0.63	0.91
Heating	2,270	2,208	0.70	1.00
Roofing	3,384	3,369	1.05	1.51
Window & Door	4,614	4,370	1.40	2.01
Insulation	1,645	1,784	0.53	0.77

- Source: Joint Center for Housing Studies, 2009 & 2011

Table 7 - 5 shows the total number of home remodeling projects conducted by US homeowners in 2007 and 2009. The ratio of air conditioning to heating system projects is approximately 0.905.[8] Assuming that the relationship is stable and applies to Delaware, approximately nine air conditioning projects will be performed for every ten heating projects. Combined with the estimates from Table 7 - 4, this implies that Kent County homeowners will replace 2,205 air conditioners each year, New Castle County homeowners will replace 7,633 systems each year, and Sussex County homeowners will replace 3,316 systems. Except for the natural relationship between heating and air conditioning, there is no logical reason why an equivalent ratio could not be used between water heaters and air conditioning systems.

Combining all relevant ratios to our demand estimates for water heaters and heating systems yields forecasts for the four other projects. Table 7 - 6 shows that the projections imply that there will be approximately 29,150 window and door projects each year, as will 21,900 roofing projects, and 13,150 air conditioning projects. Approximately 11,150 Delaware homeowners are projected to perform an insulation project each year over the next ten years.

[8] ((2,096+1,957)/(2270+2208))

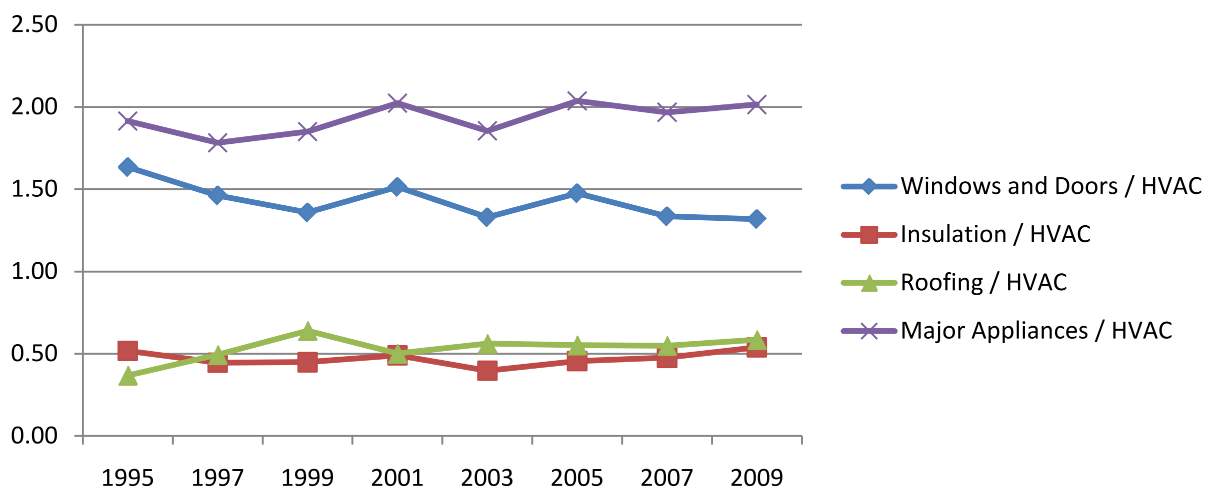
Table 7 - 6 Estimated Annual Demand Projections of Applying Ratios to Water Heater and Heating System Forecasts

	Ratio Used	Kent	New Castle	Sussex	Total
Air Conditioning	Water Heaters	2,309	7,743	3,105	13,157
	Heating System	2,205	7,633	3,316	13,154
Window and Door	Water Heaters	5,118	17,164	6,882	29,164
	Heating System	4,888	16,919	7,351	29,158
Insulation	Water Heaters	1,954	6,551	2,627	11,131
	Heating System	1,866	6,458	2,806	11,129
Roofing	Water Heaters	3,847	12,901	5,173	21,922
	Heating System	3,674	12,717	5,525	21,917

- Source: Center for Applied Demography & Survey Research

Although both ratios predict extremely close forecasts at the state level, that precision is solely due to the coincidence that our projections for annual water heater and heating system for the state form a ratio nearly identical to the national 2 year average. Looking at the history of such ratios (see Figure 7 - 4), we can see that the relationships are not perfectly stable, but they are reasonably consistent. However, the trends also indicate that an increasing proportion of home improvement projects involve insulation.

Figure 7 - 4 Historical Trends in Home Improvement Project Ratios to Windows and Doors, by Type



- Source: Joint Center for Housing Studies, 2011

Table 7 - 7 Estimated Annual Demand Forecast for Residential Equipment (2011-2021), by County

	Kent	New Castle	Sussex	Delaware	Avg. Project Cost	Expenditures
Insulation	1,910	6,504	2,716	11,130	$1,031	$11,470,967
Water Heaters	3,652	12,248	4,911	20,812	$658	$13,685,900
Air Conditioning	2,257	7,688	3,211	13,155	$3,740	$49,206,110
Heating System	2,436	8,433	3,664	14,533	$2,739	$39,809,687
Windows and Doors	5,003	17,041	7,117	29,161	$2,662	$77,624,685
Roofing	3,761	12,809	5,349	21,919	$5,071	$111,148,821
					Total	$302,946,170

- Source: Forecasts from Center for Applied Demography & Survey Research; Average project costs obtained from Joint Center for Housing Studies (2011) and inflated to 2010 $.

Table 7 - 7 summarizes the forecasts of this section. Using average project costs from the JCHS (2011) report, we project that existing Delaware homeowners will spend nearly $11.3 million on insulation projects and $109.4 million on roofing projects each year. Nearly $89 million is forecasted to be spent on HVAC repairs and replacements, $77 million on windows and doors, and $13.7 million on water heaters. In total, this method predicts that Delaware homeowners will spend $302.9 million per year on these six types of construction projects.

Table 7 - 8 Estimated Annual Demand Forecast for Residential Equipment (2011-2016), by County

	Kent	New Castle	Sussex	Delaware	Avg. Project Cost	Expenditures
Insulation	1,738	6,130	2,484	10,352	$1,031	$10,668,885
Water Heaters	3,652	12,248	4,911	20,812	$658	$13,685,900
Air Conditioning	2,054	7,245	2,936	12,236	$3,740	$45,765,478
Heating System	1,988	7,454	3,058	12,501	$2,739	$34,241,849
Windows and Doors	4,554	16,060	6,508	27,122	$2,662	$72,196,946
Roofing	3,423	12,071	4,892	20,387	$5,071	$103,376,979
					Total	$279,936,037

- Source: Forecasts from Center for Applied Demography & Survey Research; Average project costs obtained from Joint Center for Housing Studies (2011) and inflated to 2010 $.

Table 7 - 8 performs a similar analysis to the expenditures expected to occur more immediately over the next five years (2011-2016). Comparing the two forecasts, we see that the forecasted number of projects occurring over the next five years is fewer than the forecast over the next 10 years. The 10 year average predicts that Delawareans spend nearly $303 million each year. According to the 5 year forecasts, Delawareans are expected to spend nearly $280 million each year on these energy-related construction projects. Because we do not evaluate any new construction in our forecasts, this difference is solely attributed to the large bulk of housing currently between 0-4 years of age that will likely need equipment replaced between 2016 and 2021, which increase the annual average estimate over the next decade.

In the next section, we ignore the age distributions of water heaters and heating equipment entirely, and approach demand forecasts from an entirely different angle. We create a statistical model of household behavior using microdata from the American Housing Survey. Once this model is constructed, we input data obtained from Delaware's household survey (excluding equipment age) to estimate the annual number of projects and expenditures. Although we should not expect to get the same values in both approaches, it is reasonable to expect a fair degree of congruence between the two approaches.

Modeling Household Demand: Econometric Approach

In this section, we use a statistical model to estimate the likely residential expenditures for the six types of residential equipment critical to energy consumption. The model has effectively two steps, and more detail on the technical aspects can be found in the appendix. Briefly, the first step estimates the probability that a household made an energy efficient modification during the last two years, and the second step estimates the cost of such a project. Each step establishes a statistical relationship with household characteristics.

The advantage of the model is that it allows us to predict the probabilities and expenditures of home remodeling projects based upon different household characteristics. Other than equipment age, this is something the demographic approach ignores. Once the model is established, we can use the household characteristics collected in the survey to estimate the amount of spending likely attributable to such home remodeling projects.

To estimate the model, we relied on data from the 2009 American Housing Survey (AHS). The AHS data randomly samples US households and provides detailed household and geographic information, as well as information on home remodeling projects that were completed over the last 2 years. By using the AHS data, we are deriving a national model of household behavior and project costs. Therefore, the estimates we create for Delaware are synthetic in the sense that they are derived by feeding state-specific information into a national model.

Table 7 - 9 US Households with an Energy-Related Remodeling Project in the Previous 2 Years, by Pro and DIY

	Households (thousands)	Pro Projects	DIY Projects	Avg Cost	Avg Cost Pro	Avg Cost DIY
Insulation	3,667	1,737	1,930	$1,178	$1,763	$651
Water Heater	6,639	4,197	2,442	$680	$827	$425
Air Conditioning	3,981	3,493	488	$3,835	$3,992	$2,714
Heating System	4,479	3,702	777	$3,033	$3,208	$2,194
Windows and Doors	8,933	5,422	3,511	$2,752	$3,716	$1,260
Roof	6,788	5,407	1,381	$5,218	$5,887	$2,599
Total*	23,400	17,191	7,947	$4,174	$4,906	$1,678

- Source: Authors' tabulations of the 2009 American Housing Survey

* Individual elements do not sum to total because each household can report multiple projects. 2010 dollars.

As before, we define our list of energy-efficient home remodeling projects to include insulation, water heaters, air conditioner systems, heating systems, windows and doors, and roofs. We also combined all of the spending on these projects together into one aggregate group. Table 7 - 9 shows the number of households in the AHS sample that report one of these projects. Windows and doors are the most common improvement project, followed by roofs and water heaters. Of course, not all energy efficient remodeling projects have the same cost. For example, projects involving water heaters are generally much cheaper than projects involving roofs.

Costs can vary for similar projects for different reasons. For example, Table 7 - 9 indicates that there is a substantial cost differential between projects where a professional does the installation or repair (Pro) versus when a homeowner does it (DIY). For example, insulation projects performed by professionals were nearly $1,100 more expensive than insulation projects performed by homeowners. This is partially due to additional labor costs, and partially due to differences in the type of projects performed. The point is that many factors can influence the cost of a project, and the second part of the model finds statistical relationships between project costs and theoretically important and practically useful variables.[9]

[9] The model is intended to be used for predictive purposes, not causal inference. However, it is still important that the statistical relationships described by the model reasonably fit our expectations.

Table 7 - 10 Variables Created from AHS to be Included in Econometric Model

Home	Person	Geographic	Project Information
Square Feet (log)	Income 0K-15K	West*	Type of Project
Sq. Ft. < 800 Dummy	Income 15K-25K	South	Cost of Project
Sq. Ft. ≥ 7500 Dummy	Income 25K-35K	Northeast	Government Assistance
Sq. Ft. Missing	Income 35K-45K	Midwest	Project DIY
Single Family, Detached	Income 45K-55K	Urban*	
Single Family, Attached*	Income 55K-75K	Suburban	
Mobile Home	Income 75K-100K	Rural	
1-Story Building*	income 100K-120K	Degree Day 1 – Coldest*	
2-Story Building	income 120K-150K	Degree Day 2 – Cold	
3-Story Building	income 150K+*	Degree Day 3 – Cool	
Electric Heating System*	# of Persons in HH	Degree Day 4 – Mild	
Piped Gas Heating System	Single Adult HH	Degree Day 5 – Mixed	
Bottled Gas Heating System	High School or Less	Degree Day 6 – Hot	
Fuel Oil Heating System	Some College		
Other Heating System	Bachelor's Degree		
Home Age, 1-5*	Graduate Degree*		
Home Age, 6-10	Person Moved Within 2 Years		
Home Age, 11-15	Person Age		
Home Age, 16-20	Person Age Squared		
Home Age, 21-25	Race, white*		
Home Age, 26-30	Race, nonwhite		
Home Age, 31-35	Male		
Home Age, 35-40	Female		
Home Age, 41-49	Monthly Electric Bill		
Home Age, 50-59	Electric Bill Topcode (> $445)		
Home Age, 60-69	Missing Monthly Electric Bill		
Home Age, 70-79	Monthly Gas Bill		
Home Age, 80-89	Gas Bill Topcode (> $343)		
Home Age, 90+	Missing Monthly Gas Bill		

* Variable part of base group for indicator dummy variables.

Table 7 - 10 lists the theoretically important and practically useful variables that are included in our predictive model. The model finds the statistical relationship between each of these variables and the main factors of interest (probability and cost) while simultaneously controlling for the effects of all other variables. A more formal discussion is given in the appendix.

The main relationships found by this model are detailed below.

Probability of Conducting an Energy Related Project

A probit model derived a statistical relationship between the household characteristics and each of the different type of projects. In general, a home's square footage was a significant predictor to the probability that an insulation project, a heating system project, or an air conditioning project would be performed. Larger homes were more likely to conduct one of these three projects, especially if they are a detached, single family home. On the other hand, homes with two or more floors were less likely to repair or replace insulation, water heaters, windows and doors, or roofs. As expected, older homes were more likely to conduct one of these projects. Except for roofing and insulation projects, homes older than 16 years of age were equally likely to have an energy saving improvement performed, all other factors the same.

Geographical factors also were significant predictors. In general, the colder the weather, the more likely an insulation, heating system, window and door, or roofing project would be performed. Households in hotter climates were more likely to do air conditioning projects. The region of the country was also important, with more roofing and air conditioning projects being performed in the South and Midwest relative to the West. People living in a rural location also were statistically more likely to do projects involving water heaters and less likely to do projects involving windows and doors compared to homeowners in an urban environment.

In general, households with less income were less likely to do any one of these projects. Households in which the homeowner interviewed was nonwhite or had no education beyond a high school degree were also less likely to have performed a remodeling project. People who recently moved into a new home were more much likely perform these types of projects, as were households with a greater number of persons.

The relationship between homeowner behavior and household equipment also matched our expectations. Homeowners with high electric bills were more likely to repair or replace their water heaters, heating systems, air conditioners, and windows and doors. Homeowners with high natural gas bills were more likely to lay insulation and repair or replace their roofs. The type of fuel used for heating purposes also influenced the decision to repair or replace the water heater, heating system, or air conditioning systems.

Cost of Conducting an Energy Related Project

An ordinary least squares regression made a statistical link between total household expenditures and household characteristics. As before, most of the statistically significant relationships conform to our prior expectations. In this section, we briefly describe what relevant relationships were implied by this model.

Housing characteristics were most important to the costs of air conditioning, heating systems, windows and doors, and roofing projects. In general, as the square footage of the house increased, so too did the costs of these projects. Also, older homes tended to have more expensive air conditioning projects and window and door projects. Roofing projects are most expensive when the home is between 25 and 30 years old, or when it is more than 80 years old. The type of fuel used to heat the home was not especially important to the cost of projects, all else equal.

Geographic factors are also important in predicting project costs, though these factors are less important than they are in estimating the probability of conducting a project. Climate, for example, was significant with respect to the cost of roofing projects.[10] Except for insulation, project costs were generally highest in the West and lowest in the Northeast. Rural locations also tended to have less expensive windows and doors projects compared to urban locations.

For person specific variables, income was very important to project costs. As expected, persons with less income performed projects that had lower costs. This pattern is especially strong in projects involving air conditioning systems, and windows and doors. Single-adult households, households comprised of nonwhite persons, and households with less education also tended to perform projects that had lower costs than other households. The total monthly electric bill and the total monthly gas bill were also strongly correlated to the total project cost. In general, as the monthly price of electricity and natural gas increased by $1, the total project costs increased by $3.76 and $5.94 respectively, though that varied for different types of remodeling projects. This is expected since different projects have different economic returns.

Project specific characteristics were also important. For example, government assistance tends to raise the total cost of energy efficient projects. Now this is either because consumers choose to do larger projects using government aid or because professionals raise the price of their services when households rely on such assistance. Similarly, the cost of having a professional perform a project was significantly higher than the cost of doing a project by oneself. Of course, this could reflect the fact that professionals perform larger projects, or it could reflect the fact that DIY projects have lower labor costs.

[10] Climate seems most important in estimating the probability that a project gets performed (step 1).

Using the Model to Create Delaware-Specific Estimates

Once the national model was estimated, we entered data from the household survey to create synthetic estimates for the state. This process involved constructing the variables listed in Table 7 - 10 for Delawareans.[11] Table 7 - 11 compares the average values from the AHS sample (total US) to each Delaware county obtained from this survey.

The table shows that Delaware homeowners are distinct from the national average in many key areas. Geographically, both southern and northern Delaware are “cool weather” (National Climactic Data Center, 2011) climates, but only 22% of US homeowners share the same type of climate. Similarly, although officially considered in the South, Delaware is socioeconomically much closer to the Northeast region which represents 18% of US homeowners. Proportionately more New Castle County homeowners reported living in a suburban location than in the nation, while Kent and Sussex county homeowners were more likely to report living in a rural environment.

Relatively fewer New Castle homeowners reported living in a mobile home compared to the US average, but relatively more did in Kent and Sussex. Unit area was also substantially larger in Delaware than in the nation. New Castle County homeowners were more likely living in housing stock that resembled the national age distribution, but homeowners in Kent and Sussex counties tended to live in newer units. Delaware homeowners also heat their homes using a different composition of fuel than the national average. Electricity and natural gas bills (nominal $) were also much larger for Delawarean homeowners than in the nation. This is evident both in the average bill and the relative proportion of topcoded values.

[11] Since the AHS topcoded some variables, the corresponding Delaware variables had to be adjusted as well. For example, the AHS reported any household’s monthly electricity bill in excess of $445 to be $548 instead of the true value. Both sets of data were also adjusted in response to reflect our econometric modeling decisions (e.g. squaring household age, grouping home ages, creating dummy variables indicating topcoded observations, etc.).

Table 7 - 11 Comparison of Homeowner Characteristics in each Delaware County and the Nation

	NCC	KNT	SSX	US
Degree Day 1 - Coldest	0%	0%	0%	10.7%
Degree Day 2 - Cold	0%	0%	0%	26.7%
Degree Day 3 - Cool	100%	100%	100%	22.2%
Degree Day 4 - Mild	0%	0%	0%	19.6%
Degree Day 5 - Mixed	0%	0%	0%	12.3%
Degree Day 6 - Hot	0%	0%	0%	8.6%
Square Feet**	2170	2283	2262	2005
Sq. Ft. l.t. 800	4.2%	2.9%	6.4%	3.3%
Sq. Ft. g.t.e 7500	0%	0%	0%	1.2%
Single Family, Attached	18%	7%	4%	10.1%
Single Family, Detached	80.5%	85.8%	84.8%	82.9%
Mobile Home	1.6%	7.4%	11.2%	7.1%
1-Story Building	20.3%	49.1%	58.3%	41.4%
2-Story Building	66.4%	47.5%	39.2%	33.0%
3-Story Building	13.3%	3.4%	2.5%	25.6%
West	0.0%	0.0%	0.0%	20.4%
South	0.0%	0.0%	0.0%	38.2%
Northeast	100%	100%	100%	17.5%
Midwest	0%	0%	0%	23.9%
Urban	15.9%	14.1%	11.2%	22.5%
Suburban	75.4%	35.2%	34.9%	42.5%
Rural	8.8%	50.7%	53.9%	35.0%
Income 0K-15K	2.8%	4.6%	6.5%	9.4%
Income 15K-25K	3.8%	7.3%	5.6%	8.1%
Income 25K-35K	5.0%	7.9%	8.0%	10.6%
Income 35K-45K	6.0%	9.6%	11.2%	9.4%
Income 45K-55K	8.3%	11.9%	8.5%	8.8%
Income 55K-75K	16.0%	17.9%	21.3%	14.2%
Income 75K-100K	24.7%	19.6%	18.1%	14.2%
income 100K-120K	12.7%	11.6%	8.3%	7.9%
income 120K-150K	9.5%	5.2%	6.9%	6.9%
income 150K+	11.4%	4.3%	5.6%	10.5%
Electric Heating System	27.4%	26.1%	38.8%	29.3%
Piped Gas Heating System	49.3%	42.2%	16.8%	53.9%
Bottled Gas Heating System	2.4%	11.4%	19.1%	6.4%
Fuel Oil Heating System	19.0%	15.3%	17.5%	7.4%
Other, Non-electric Heating System	1.9%	5.0%	7.8%	2.9%

- Source: Center for Applied Demography & Survey Research, and 2009 American Housing Survey.

** Outliers have been removed and conditional average reported. Adjustments made in modeling.

Table 7 - 11 Comparison of Homeowner Characteristics in each Delaware County and the Nation (cont)

	NCC	KNT	SSX	US
Home Age, 1-5	5.1%	18.5%	18.3%	6.0%
Home Age, 6-10	9.0%	20.8%	21.7%	8.3%
Home Age, 11-15	8.8%	10.1%	12.6%	8.1%
Home Age, 16-20	11.9%	10.8%	10.6%	6.2%
Home Age, 21-25	8.9%	6.0%	5.5%	6.8%
Home Age, 26-30	5.1%	6.5%	6.3%	5.5%
Home Age, 31-35	5.1%	3.4%	2.9%	9.8%
Home Age, 35-40	7.9%	4.4%	5.5%	7.5%
Home Age, 41-49	15.0%	5.6%	4.2%	11.7%
Home Age, 50-59	10.1%	4.0%	3.9%	11.2%
Home Age, 60-69	2.5%	2.2%	2.7%	5.8%
Home Age, 70-79	3.9%	1.2%	1.3%	3.8%
Home Age, 80-89	2.0%	0.4%	0.4%	3.3%
Home Age, 90+	4.7%	6.1%	4.1%	6.2%
# of Persons	2.93	2.66	2.57	2.62
Single Adult Household	16.2%	16.3%	17.2%	25.0%
High School or Less	28.0%	31.9%	35.4%	37.5%
Some College	21.5%	33.1%	26.8%	28.7%
Bachelor's Degree	30.4%	20.3%	22.8%	20.8%
Graduate Degree	20.1%	14.6%	15.0%	13.0%
Moved Within 2 years	9.5%	13.4%	8.5%	11.3%
Person Age	47.1	47.8	53.3	52.9
Race, nonwhite	19.3%	16.2%	8.6%	13.7%
Female (Interviewee)	52.1%	51.6%	51.1%	57.7%
Monthly Electric Bill (nominal $)**	$209.85	$178.84	$189.76	$132.78
Electric Bill g.t. 445	7.2%	2.8%	3.2%	0.8%
Monthly Electric Bill n/a	0.3%	0.5%	0.2%	0.7%
Monthly Gas Bill (nominal $)**	$151.34	$136.36	$152.89	$89.86
Monthly Gas Bill g.t. 343	5.2%	2.5%	5.8%	0.7%
Monthly Gas Bill n/a	59.0%	62.0%	84.4%	32.7%
Government Assistance	0%	0%	0%	1.0%

- Source: Center for Applied Demography & Survey Research, and 2009 American Housing Survey.

** Outliers have been removed and conditional average reported. Adjustments made for modeling purposes.

Table 7 - 12 Annual Probability an Average Household Conducts a Project Related to Energy, by County and Type

	Kent	New Castle	Sussex
Insulation	1.8%	2.1%	1.6%
Water Heater	3.7%	4.7%	3.5%
Air Conditioning	1.7%	2.4%	1.6%
Heating System	2.9%	3.6%	2.8%
Windows and Doors	5.3%	6.8%	4.9%
Roof	3.4%	3.8%	3.3%
Any EE Project	13.0%	15.6%	12.6%

- Source: Center for Applied Demography & Survey Research

Finally, homeowner characteristics also differed from the national average. The household income distribution, for example, shows Delaware to have a relatively larger proportion of upper-middle homeowners than the nation. In addition, New Castle County homeowners were less likely to have a high school degree or lower level of education and more likely to have a graduate degree compared to the national average. Fewer Delawarean homeowners reported living in a single adult household compared to the national average.

We should caution that while the estimates derived in Table 7 - 11 yield our best estimates for Delawarean homeowners, they include uncertainty due to sampling. For the purposes of estimating demand forecasts, we ignore such issues. Instead of computing estimates using survey averages, a predicted probability and cost was generated for each observation in our survey, and those predicted values were then weighted using the given sampling weights.

Table 7 - 12 indicates the average probability that a household in each county would perform an energy efficient project in one year. The model predicts that 15.6% of homeowners in New Castle County, 13.0% of homeowners in Kent County, and 12.6% of homeowners in Sussex County will perform at least one of these six projects per year. The most common projects involve windows and doors, followed by water heaters and roofing repairs. The model predicts that insulation projects will be least common.

Table 7 - 13 Average Expected Cost (2010 $) per Energy Efficient Project, by County and Project Type

	Kent	New Castle	Sussex
Insulation	$926	$1,033	$849
Water Heater	$724	$808	$698
Air Conditioning	$4,016	$4,181	$4,063
Heating System	$2,892	$3,062	$2,923
Windows and Doors	$1,814	$2,663	$1,765
Roof	$3,780	$4,728	$3,767
Any EE Project	$3,266	$4,073	$3,194

- Source: Center for Applied Demography & Survey Research

Table 7 - 13 predicts the average cost per project in each category. In general, the most expensive projects are forecasted to occur in New Castle County. Comparing these results to those in Table 7 - 9 finds that some of the construction projects in New Castle County, for example HVAC related repairs and water heaters, are expected to be more expensive than the national average. This partially reflects the fact that New Castle County has an older housing stock than the other two counties, and partially reflects the fact that the typical New Castle County household has an above average income and level of education.

The model predicted that roofing was the most expensive project in Delaware, and water heater projects the least expensive. The average cost of replacing windows and doors was expected to be nearly $800-$900 more expensive in New Castle County than in Kent or Sussex. Insulation was expected to be relatively cheap in Delaware compared to the national average (Table 7 - 9), which may stem from Delaware's more moderate climate relative to the national average.

Table 7 - 14 Predicted Annual Expenditures (2010 $) of Energy Efficient Projects in Delaware, by County and Project

	Kent	New Castle	Sussex	Total
Insulation	$1,724,506	$7,043,809	$1,828,723	$10,597,038
Water Heater	$2,431,962	$10,916,394	$2,912,594	$16,260,950
Air Conditioning	$6,705,354	$29,681,166	$8,911,074	$45,297,594
Heating System	$8,158,832	$33,245,750	$10,663,346	$52,067,928
Windows and Doors	$11,284,071	$57,653,068	$12,932,740	$81,869,879
Roof	$13,566,772	$55,336,080	$16,984,212	$85,887,064
Total	$43,871,497	$193,876,267	$54,232,689	$291,980,453

- Source: Center for Applied Demography & Survey Research

Table 7 - 14 reports the total annual expenditures that Delawareans are expected to make on the six types of projects critical to energy efficiency. Roofing projects and projects involving windows and doors are expected to receive the most expenditure. Combined, these two types of exterior projects represent nearly 57% of Delaware's expected spending on these six projects. The model also finds that both heating and air conditioning systems are likely to draw nearly $97 million per year from Delawarean homeowners. Projects involving insulation and water heaters are not expected to take up that much of the expenditures.

Between the three Delaware counties, homeowners in New Castle account for nearly two thirds of expected spending on these projects. This is both because more homeowners are expected to perform projects in New Castle County, and because the costs of those projects are expected to be larger.

Comparison of Forecasts between the Two Approaches

We summarize the results of our two forecasts in this section. Recall that the first approach used a combination of demographic assumptions and national ratios to infer the future demand for Delawarean homeowners. This was done for both the average number of projects expected to occur between 2011 and 2021 as well as the more average between 2011 to 2016. The second approach derived a national statistical model of homeowner behavior and project costs, and then incorporated Delaware-specific data into that model to predict average expenditures. Table 7 - 15 indicates the projected number of projects and expenditures each year over the next decade.

There are some minor discrepancies between the two approaches. The demographic approach for example, estimated 1,571 insulation projects will be performed in Kent County each year over the next five years, while the econometric approach estimates this figure to be 1,690. Other estimated projections show larger differences. For example, the econometric model predicts that 13,476 water heaters will be needed in New Castle County each year, while the 5-year demographic projection estimates that only 10,742 water heaters will be replaced.

Despite these individual discrepancies, there is a high degree of similarities between the two forecasts. Correlating the annual five-year demographic forecast with the econometric forecast for the number of projects returns a value of 0.980. Correlating the expenditures returns a value of 0.951. Clearly, both methods are quite consistent in their projections.[12]

[12] Comparing the forecasts of water heaters and heating equipment alone yields correlations of 0.994 and 0.996 for total projects and expenditures, respectively.

Table 7 - 15 Comparison of Projected Annual Demand and Expenditures in each Approach, by County

		Forecasted Annual Projects				Forecasted Annual Expenditures			
		Kent	New Castle	Sussex	Total	Kent	New Castle	Sussex	Total
5-Yr Age Dist. Forecast	Insulation	1,571	5,727	2,205	9,502	$1,619,009	$5,902,189	$2,272,302	$9,793,501
	Water Heaters	3,027	10,742	3,867	17,636	$1,990,736	$7,063,857	$2,542,716	$11,597,309
	Air Conditioning	1,857	6,769	2,606	11,232	$6,944,937	$25,318,159	$9,747,315	$42,010,411
	Heating Equipment	1,988	7,454	3,058	12,501	$5,446,744	$20,419,347	$8,375,758	$34,241,849
	Windows and Doors	4,116	15,004	5,777	24,896	$10,955,927	$39,940,449	$15,376,795	$66,273,171
	Roofs	3,094	11,278	4,342	18,714	$15,687,515	$57,189,718	$22,017,644	$94,894,876
					Total	$42,644,869	$155,833,720	$60,332,529	$258,811,118
		Kent	New Castle	Sussex	Total	Kent	New Castle	Sussex	Total
10-Yr Age Dist. Forecast	Insulation	1,910	6,504	2,716	11,130	$1,968,061	$6,703,476	$2,799,431	$11,470,967
	Water Heater	3,652	12,248	4,911	20,812	$2,401,883	$8,054,356	$3,229,661	$13,685,900
	Air Conditioning	2,257	7,688	3,211	13,155	$8,442,236	$28,755,375	$12,008,499	$49,206,110
	Heating System	2,436	8,433	3,664	14,533	$6,673,548	$23,099,838	$10,036,302	$39,809,687
	Windows and Doors	5,003	17,041	7,117	29,161	$13,317,978	$45,362,801	$18,943,906	$77,624,685
	Roof	3,761	12,809	5,349	21,919	$19,069,676	$64,953,846	$27,125,300	$111,148,821
					Total	$51,873,381	$176,929,692	$74,143,098	$302,946,170
		Kent	New Castle	Sussex	Total	Kent	New Castle	Sussex	Total
Econometric Forecast	Insulation	1,690	6,033	1,914	9,637	$1,724,506	$7,043,809	$1,828,723	$10,597,038
	Water Heater	3,400	13,476	4,305	21,181	$2,431,962	$10,916,394	$2,912,594	$16,260,950
	Air Conditioning	1,515	6,782	1,962	10,259	$6,705,354	$29,681,166	$8,911,074	$45,297,594
	Heating System	2,618	10,325	3,376	16,319	$8,158,832	$33,245,750	$10,663,346	$52,067,928
	Windows and Doors	4,897	19,387	5,931	30,214	$11,284,071	$57,653,068	$12,932,740	$81,869,879
	Roof	3,122	10,780	4,043	17,945	$13,566,772	$55,336,080	$16,984,212	$85,887,064
					Total	$43,871,497	$193,876,267	$54,232,689	$291,980,453

- Source: Center for Applied Demography & Survey Research

Table 7 - 16 Final Forecasts of Consumer Demand for Energy-Related Residential Construction

	Kent	New Castle	Sussex	Total
Insulation	1,800	6,269	2,315	10,384
Water Heater	3,526	12,862	4,608	20,996
Air Conditioning	1,886	7,235	2,587	11,707
Heating System	2,527	9,379	3,520	15,426
Windows and Doors	4,950	18,214	6,524	29,688
Roof	3,442	11,795	4,696	19,932

	Kent	New Castle	Sussex	Total
Insulation	$1,846,284	$6,873,643	$2,314,077	$11,034,003
Water Heater	$2,416,923	$9,485,375	$3,071,128	$14,973,425
Air Conditioning	$7,573,795	$29,218,271	$10,459,787	$47,251,852
Heating System	$7,416,190	$28,172,794	$10,349,824	$45,938,808
Windows and Doors	$12,301,025	$51,507,935	$15,938,323	$79,747,282
Roof	$16,318,224	$60,144,963	$22,054,756	$98,517,943
Total	$47,872,439	$185,402,980	$64,187,894	$297,463,312

- Source: Center for Applied Demography & Survey Research

The final projection of future consumer demand is given in Table 7 - 16. The values were obtained by taking the midpoint between the ten year demographic projection and the econometric forecast. In total, we estimate that nearly $300 million will be spent each year on these six projects. Windows and doors will be the most common project, followed by water heaters and then roofs. However, because water heater installation projects are also the cheapest type of projects, only $15 million is expected to come from that expenditure. Roofing is expected to be the most expensive project, and captures nearly a third of consumer expenditures.

The final step of our forecast is to translate these expenditures to employment.

Table 7 - 17 Net Receipts, Payroll, Employees, and Wages of Relevant Construction Industries in Delaware, 2007

Type of Contractor	NAICS	Net Receipts	Total Payroll	Total Employees	Annual Wage
Residential Remodelers	236118	$167,356	$39,054	993	$39,329
Roofing	238160	$99,245	$23,914	572	$41,807
Plumbing & HVAC	238220	$688,844	$242,820	4,907	$49,484
Drywall & Insulation	238310	n.a.	$46,734	1,059	$44,131

- Source: 2007 Economic Census, Table ECO2731A

* Receipts net of contract work and payroll are expressed in thousands of 2010 $. Wages are in 2010 $.

The Direct Impact on Labor

Using data from the 2007 Economic Census of the construction sector, Table 7 - 17 reports the net receipts, payroll, employment, and the annual wage for construction industries relevant to the six projects. We assume that professionally done insulation projects are performed by drywall and insulation contractors. Similarly, professionally installed or repaired water heaters, air conditioning, and heating systems are done by plumbers and HVAC contractors. Similarly, roofing contractors work on roofs, and residential remodelers are assumed to perform professionally done window and door projects.

Of course, not all of the residential remodeling expenditures will go to contractors, because some of those expenses will be spent on DIY projects. Table 7 - 18 reports what fraction of DIY projects we assume for each project.[13] Although household expenditures technically reflect total receipts, construction companies often contract some of their work out to other businesses. Assuming that the contracted company has the same number of employees to net receipts, the draw on labor demand can be estimated using the ratio of net receipts to employees.[14]

[13] Estimates derived using tabulated values from AHS. See Table 7 - 9.

[14] Where Delaware specific data is not available in the 2007 Economic Census, ratios were taken for each surrounding state and the average was used to estimate net receipt to employee ratios.

Table 7 - 18 Assumptions Related to the Direct Economic Impact of Residential Construction Expenditures

	Relevant Industry (NAICS)	% to Professional	Net Receipts per Employee	Avg. Wage per Employee
Insulation	238310	70.9%	$142,092*	$44,131
Water Heater	238220	77.0%	$140,380	$49,484
Air Conditioning	238220	91.3%	$140,380	$49,484
Heating System	238220	87.4%	$140,380	$49,484
Windows and Doors	236118	82.0%	$168,536	$39,329
Roof	238160	89.9%	$173,505	$41,807

- Source: Author's calculations of the 2007 Economic Census (ECO2731A) and 2009 American Housing Survey.

* Figure estimated as the average of ratios calculated for Pennsylvania, Maryland, and New Jersey.

Table 7 - 19 Projected Annual Labor Demand and Wages for Energy-Related Residential Projects

	Employment				Wages (000's)			
	Kent	New Castle	Sussex	Total	Kent	New Castle	Sussex	Total
Insulation	9	34	12	55	$407	$1,514	$510	$2,430
Water Heater	13	52	17	82	$656	$2,574	$833	$4,063
Air Conditioning	49	190	68	307	$2,438	$9,406	$3,367	$15,212
Heating System	46	175	64	286	$2,286	$8,684	$3,190	$14,161
Windows and Doors	60	251	78	388	$2,354	$9,856	$3,050	$15,259
Roof	85	312	114	510	$3,534	$13,024	$4,776	$21,333
Total	262	1,014	353	1,629	$11,674	$45,058	$15,726	$72,458

- Source: Center for Applied Demography & Survey Research

Table 7 - 19 indicates the projected annual employment and wages in the construction sector due to Delaware homeowners performing one of the six types of residential construction projects. Altogether, these six projects are forecasted to use 1,629 employees and pay wages of nearly $72.5 million each year. The demand for labor is greatest due to homeowners in New Castle County, which creates the demand for nearly 1,000 employees and $45 million in wages.

If we treat air conditioning and heating separately, roofing is expected to create the single largest demand on Delaware's workforce (over 500 employees). Air conditioning and heating systems are each expected to generate demands for approximately 300 workers. Almost 400 persons will be working in the state to repair and replace windows and doors. Insulation is not expected to demand much labor from households, needing only 55 workers per year for the entire state.

The estimates forecasted in Table 7 - 19 indicate that residential remodeling on these energy-related construction projects is expected to capture approximately 7.6% of employment in Delaware's construction sector, which is itself 5.4% of the state's total covered employment.[15] Therefore, total residential demand for energy-related remodeling projects is expected to impact approximately 0.4% of Delaware's covered employment. The expected wages from these projects also represent approximately 0.4% of wages in the state.

The implication from these numbers is important, because residential household energy efficiency is often been touted as a major component of the green job strategy. Despite using two different forecasting techniques, we reached similar conclusions regarding probable household expenditures for key green-related construction projects. Even if all of these projects were considered green, the private demand stemming from the existing housing stock affects just 0.4% of Delaware's workforce.

[15] According to preliminary estimates for 2010, the Quarterly Census of Employment and Wages, total covered employment was 399,327 in the state and 21,521 in the construction sector. Similarly, total annual wages were reportedly $19.2 billion for the state and $1.0 billion for the construction sector.

Observations and Conclusion

This report has covered the household contribution to the green economy from a number of different angles. We chose to focus this report on households for two reasons. First, households provide businesses with the supply of green jobs. Although many green job reports have covered green goods and services by interviewing businesses, few have attempted to cover green work activities by interviewing employees. Those that do explore green work activities are often constrained to introducing new theoretical categorizations instead of empirical analysis. Of course, research in this area is still nascent, and analytical frameworks are still being developed.

The other reason we focused on households was because of their role as consumers. Although the underlying theme of the series relates to green *jobs*, the consumer is as important to jobs as are businesses. In the green economy, there are typically three consumers: the government, other businesses, and households. Persons who invest in learning green job skills do so because they believe the long term benefits of those skills outweigh the short term investment costs. Although government demand currently plays a very large role in the green economy, conventional market forces are likely to be more reliable indicators of future labor demands.

This report primarily addressed the households' demand for energy efficient goods and services. Although demand for many types of green products affects green jobs, we focus on energy efficiency for a number of reasons. First, energy efficiency has been cited as the cheapest way to cut pollution, and from an economic lens, it is simply wasteful to spend more than is necessary to cut pollution. Second, energy efficiency can be achieved on a greater scale due to its lower costs. Third, most households do not view energy as a valuable good in and of itself, but instead as a resource needed to do other, valuable activities. Lowering energy costs, therefore, means that more resources can be used in ways that create the greatest value for households.

Because households use energy in different ways, it is useful to understand the typical Delaware homeowner and housing unit. Information such as housing unit age and type, age of residential equipment, household income, education, energy bills, etc. are each important determinants of the type of energy savings possible and the demand that will likely exist. In turn, this information can be used to tailor relevant policies to Delaware homeowners. For example, the recent surge of new housing in Kent County implies that as a percentage of the housing stock, proportionally fewer homes in Kent County would likely undertake an energy audit.

While the housing unit plays a large role in determining which energy-saving opportunities are available, other factors also matter when determining demand. Behavioral issues are one such factor. For example, our survey found that 17% of households could immediately begin saving energy if they only used their programmable thermostat. Similarly, nearly a third of homeowners with a forced air system have not replaced their system’s air filter in more than three months. Despite the fact that households use more energy than necessary, 95% feel that conserving energy is a worthwhile goal. In fact, most households think that they already conserve energy (80%) and do even more to reduce pollution (60%).

Perceptions are a major issue in energy efficiency. At its most basic level, energy efficiency comes down to the perception of how much energy households *should* be using. On one hand, energy efficiency can be viewed as reducing energy use to the minimum amount necessary to achieve a fixed goal, such as heating or cooling a home. On the other hand, energy efficiency can be viewed as reducing energy use from what would have otherwise been used. For a household that uses substantial amounts of energy, any reduction is seen as being *more energy-efficient*, rather than *less energy-inefficient*. Differences in perceptions mean that households can think they are becoming more energy efficient, despite using more energy.

Of course, perceptions can change. Witness the household’s much greater acceptance of hybrid vehicles over all electric vehicles. Though we cannot be certain, it is possible, if not likely, that previous perceptions of hybrid vehicles resembled that of electric vehicles today.

Financial considerations are also very important. The survey found that the average homeowner demands extremely high rates of return on energy saving investments. In one such scenario, the minimum acceptable rate of return for an energy saving investment approached 50% (APR). These extremely high thresholds could be due to the inherent risk of these investments. Unforeseen energy price fluctuations and foreseeable changes in the decoupling of transmission and generation pricing both add to the risk that future benefits will not materialize as expected, regardless of energy savings. Although high upfront costs are the major reason households said they *would not* undertake an energy saving investment, expected future financial savings are the major reason why households say they *would* undertake such an investment.

Another important consideration is that household energy efficiency will occur naturally over time as old and worn out equipment gets replaced. As a result, it is inappropriate to compare the savings from new equipment to that of old equipment, because practically *all* new purchases will be considered economically and environmentally beneficial. However, if one compares new, energy efficient equipment to other new, non energy-efficient equipment, the true economic litmus test is whether the *additional* energy bill reductions are worth the *additional* costs. The environmental litmus test is how much less energy is used as a result of choosing the energy-efficient equipment.

Most households said that they would not replace an appliance until it stopped working properly, so older appliances are most likely to be replaced when rebate programs are offered. This implies that rebates do not *create* jobs, they just alter the type of appliances that would have been installed. On the other hand, such rebates may convince some homeowners to enter the market today instead of in a few years, so a short term surge can probably be expected. However, the flip side of the coin is that demand increases today at the expense of demand tomorrow. From an environmental point of view, however, rebates are clearly a good thing. Since durable residential equipment lasts for at least a decade, the decision to purchase energy efficient equipment means that real energy reductions will be long term.

Another observation is that renewable energy and energy efficiency are definitely not equivalent. Despite marketing that intermingles these two distinct areas; energy efficiency lowers pollution by reducing the demand for energy. Renewable energy lowers pollution by changing the supply of electricity. Financial differences between these two areas are quite large, with renewable energy being substantially more expensive. This implies that the potential scale of renewable energy will be far below the potential scale of energy efficiency. This economic fact pans out in the survey. Even with the federal and state support, nearly 13 times more homeowners installed energy-efficient windows and doors than conducted any type of renewable energy (including geothermal HVAC) project. Similarly, 8 times as many homeowners laid insulation to conserve energy, 6.5 times as many homeowners replaced their heating system to save energy, 5.5 times as many homeowners sealed cracks and made repairs to the home's exterior, etc.

One important consideration regarding energy efficiency is that it is possible to improve energy efficiency, but still use *more* energy. The reason for this paradox comes down to the core of microeconomic theory. Households that reduce energy costs by becoming more efficient effectively have more income to spend. Should households use that money on activities that require energy, then it is possible that more energy will be used. At the very least, these natural economic responses will offset some of the energy reductions.

Of course, households are also important to green jobs by supplying labor. Therefore, we surveyed employed homeowners about their work environment to understand how employees view energy efficiency and pollution reduction. Our results suggest that most persons think that these goals are achievable if employees merely change their behavior or if employer's choose to upgrade equipment. Very few persons indicated that training or skills were necessary. This is important because it implies that the 'process approach', which defines green jobs based on employees' work activities, will somehow need to differentiate between green work activities and behavioral changes. Most employees responded that behavioral issues were far more likely to be relevant.

The second part of this report used the results described in the first part to estimate what the likely future demand will be for certain types of home improvement projects. Since consumer demand is critically important in estimating labor demand, household needs are strongly associated with future green jobs. We focused specifically on six projects that are critical determinants of a home's energy consumption; insulation, water heaters, air conditioning, heating systems, windows and doors, and roofs. Two different approaches were used to translate household demand for these projects into probable future employment requirements.

The first approach used the age profile of Delaware's water heaters and heating systems to estimate the probable replacement needs over the next decade. The second approach developed a model of household behavior and incorporated relevant information about Delaware homeowners into that model. Both approaches yielded similar estimations for each type of project. These replacement needs were then converted into employment requirements using net receipt to employment ratios.

We estimated that current homeowner demand for these six projects will likely require 1,629 employees, on average, each year for the next ten years. Insulation projects will require the least number of persons (55 per year) while roofing projects will require the most (510 per year). Of course, the fraction of these jobs that can be considered green depends on homeowner adoption of green equipment.

Though the data was not available to estimate the demand for weatherization by itself, our survey suggests that 2 homeowners sealed cracks, repaired the exterior of their homes, and added storm doors or storm windows to save energy for every 3 homeowners that installed insulation to save energy. Since most homeowners add insulation for the express purpose of saving energy, a simple estimate suggests that nearly 7,000 homeowners in Delaware will seal cracks, repair their home's exterior, or add storm doors or storm windows each year. Unfortunately, we do not know how many of these will be DIY projects.

We should note that the long term private demand projected in this report does not take into account government programs. For example, the Weatherization Assistance Program (WAP) and the Sustainable Energy Utility (SEU) will undoubtedly stimulate more energy efficiency residential projects in the short run. The WAP currently is expending a $14 million grant from the American Recovery and Reinvestment Act (ARRA), and the SEU received $5.7 to spend on residential energy efficiency rebates. The SEU also received another $11 million of ARRA funds for financing future energy efficiency projects. The SEU also receives recurring funding from other sources. Considering that the private market expenditures for the six residential construction projects was estimated to be $300 million a year, the relative size of these government programs is still relatively small.

To the extent that these programs target households that would not otherwise be in the market or convince existing consumers to increase the scale of the projects they planned on doing, additional labor would be needed than what the private market would do in absence of these programs. Of course, to the extent that these programs pay for projects that would otherwise be done privately, no additional employment would be added to the economy, though cost burdens would change. Moreover, some jobs will necessarily be lost as a result of having to raise funds for these programs. Whether more jobs are gained than lost addresses larger economic issues that we do not explore in this report. Interested readers may turn to the fifth report of this series for a deeper analysis of these issues.

This report describes Delaware households, primarily from the standpoint of the green consumer. Many important statistics and relationships have been detailed in this report. We hope that readers can use these estimates to understand the role of the private household in the green economy.

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Appendix

Demographic Modeling of the Failure Rates for Residential Equipment

This section explains how failure rates were calculated from the age distributions of homes and residential equipment. As explained in the main text, the critical assumptions are that the failure rate of a water heater or heating system at a particular age is constant across different time periods and that every new home begins with new equipment.

More specifically, define ‘f_1’ to be the equipment failure rate of equipment aged 0-4 years, ‘f_2’ to be the equipment failure rate of equipment aged 5-9 years, ‘f_3’ to be the equipment failure rate of equipment aged 10-14 years, etc. When equipment fails, we assume that it is replaced with new equipment immediately and that the age of the new equipment is effectively 0. In addition, allow the average age of a home between 0 and 4 years to be ‘h_1’, the average age of a home between 5 and 9 years to be ‘h_2’, the average age of home between 10 and 14 years to be ‘h_3’, etc. Finally, allow the average age of equipment within 0-4 year old homes to be ‘e_1’, the average age of equipment within 5-9 year old homes to be ‘e2’, the average age of equipment within 10-14 year old homes to be ‘e_3’, etc.

Table A - 1 Average Ages of Select Residential Equipment and Homes in Delaware

	Housing Group	Total Households	Avg. Age of Home	Avg. Age of Water Heaters	Avg. Age of Heating Equipment
5-Year Cohorts	0-4	51,521	3.54	3.39	3.74
	5-9	66,923	8.36	7.00	8.12
	10-14	48,157	13.25	7.90	10.53
	15-19	50,168	18.82	7.37	10.86
	20-24	31,030	23.75	8.31	11.60
	25-29	24,532	29.20	6.90	10.74
	30-34	18,138	34.17	6.66	15.10
	35-39	28,434	39.44	6.74	14.07
10-Year Cohorts	40-49	45,704	48.16	7.06	11.58
	50-59	33,618	57.15	7.71	11.89
	60-69	10,555	67.60	6.08	10.58
	70-79	8,703	78.63	8.90	8.48
	80-89	6,107	86.98	8.22	9.73
	90+	21,543	98.82	7.75	10.99

- Source: Center for Applied Demography & Survey Research

Under these assumptions, the average equipment age in new homes is simply a weighted average of the homes' age that did not have any equipment fail $(1-f_1)\times h_1$ and the age of the new equipment that replaced the failed equipment (assumed to be zero). For example, using the results in Table A - 1, the average age of a water heater in a new home is 3.39, but the average age of the home is 3.54. This implies

1) $e_1 = (1-f_1)\times h_1 + f_1\times 0 \quad \rightarrow \quad 3.39 = (1-f_1)\times 3.54$

from which we uncover that f_1 is 0.043, or 4.3%.[16]

[16] Occasionally the reported values violated the assumptions of our model. For example, the average age of heating systems was actually more than the average age of new homes. Although we suspect this is due to coding errors or respondent errors, it is technically possible that new homes are constructed with used materials. In such cases, failure rates were constrained to be between zero and one.

Because technology is assumed constant, we assume that 95.7% of homes between the ages of 5-9 would face the equipment failure rate f_2 and the remaining 4.3% of homes that failed the first time would face the failure rate f_1 again.

2) $e_2 = (1-f_1)\times(1-f_2)\times h_2 + (1-f_1)\times f_2\times 0 + f_1\times(1-f_1)\times(h_2-h_1) + f_1\times f_1\times 0$

$7.00 = 0.957\times(1-f_2)\times 8.36 + 0.957\times f_2\times 0 + 0.043\times 0.957\times(8.36-3.54) + 0.043\times 0.043\times 0$

from which we infer that f_2 equals 15.0%. Similar steps were taken to infer f_3, for which eight possible paths were available to homes between the ages of 10 and 14 years of age. In general, each successive group of homes could have had twice as many events affect the age of their residential equipment. Therefore, each successive equation has 2^N elements. Despite the exponentially growing number of elements in each equation, if they are solved recursively beginning with the first, then the problem condenses to the trivial solution of solving single linear equations with one unknown variable. Table A - 2 demonstrates the various paths that equipment could take as houses age.

Finally, to infer the failure rate of the long tail of the distribution, we chose e_{tail} to equal the weighted average equipment age of all homes in the tail. While this solution may impose some degree of error, we conducted sensitivity tests on the effects of tail end failure rates. Those tests indicate that even relatively large deviations in the failure rate (+/- 20 percentage points) did not materially affect the total forecasts. Of course, the choice was more important to heating equipment than it was to water heaters, considering the longer tail of heating equipment age.

Table A - 2 Example of Equipment Path Failure Rates for First Five Age Groups

0-4 Years	5-9 Years	10-14 Years	15-19 Years	20-24 Years
				(1-f1)*(1-f2)*(1-f3)*(1-f4)*(1-f5)
				(1-f1)*(1-f2)*(1-f3)*(1-f4)*f5
				(1-f1)*(1-f2)*(1-f3)*f4*(1-f1)
				(1-f1)*(1-f2)*(1-f3)*f4*f1
				(1-f1)*(1-f2)*f3*(1-f1)*(1-f2)
				(1-f1)*(1-f2)*f3*(1-f1)*f2
		Equipment		(1-f1)*(1-f2)*f3*f1*(1-f1)
		Never Fails		(1-f1)*(1-f2)*f3*f1*f1
			(1-f1)*(1-f2)*(1-f3)*(1-f4)	(1-f1)*f2*(1-f1)*(1-f2)*(1-f3)
			(1-f1)*(1-f2)*(1-f3)*f4	(1-f1)*f2*(1-f1)*(1-f2)*f3
			(1-f1)*(1-f2)*f3*(1-f1)	(1-f1)*f2*(1-f1)*f2*(1-f1)
			(1-f1)*(1-f2)*f3*f1	(1-f1)*f2*(1-f1)*f2*f1
		(1-f1)*(1-f2)*(1-f3)	(1-f1)*f2*(1-f1)*(1-f2)	(1-f1)*f2*f1*(1-f1)*(1-f2)
		(1-f1)*(1-f2)*f3	(1-f1)*f2*(1-f1)*f2	(1-f1)*f2*f1*(1-f1)*f2
	(1-f1)*(1-f2)	(1-f1)*f2*(1-f1)	(1-f1)*f2*f1*(1-f1)	(1-f1)*f2*f1*f1*(1-f1)
(1-f1)	(1-f1)*f2	(1-f1)*f2*f1	(1-f1)*f2*f1*f1	(1-f1)*f2*f1*f1*f1
f1	f1*(1-f1)	f1*(1-f1)*(1-f2)	f1*(1-f1)*(1-f2)*(1-f3)	f1*(1-f1)*(1-f2)*(1-f3)*(1-f4)
	f1*f1	f1*(1-f1)*f2	f1*(1-f1)*(1-f2)*f3	f1*(1-f1)*(1-f2)*(1-f3)*f4
		f1*f1*(1-f1)	f1*(1-f1)*f2*(1-f1)	f1*(1-f1)*(1-f2)*f3*(1-f1)
		f1*f1*f1	f1*(1-f1)*f2*f1	f1*(1-f1)*(1-f2)*f3*f1
			f1*f1*(1-f1)*(1-f2)	f1*(1-f1)*f2*(1-f1)*(1-f2)
			f1*f1*(1-f1)*f2	f1*(1-f1)*f2*(1-f1)*f2
			f1*f1*f1*(1-f1)	f1*(1-f1)*f2*f1*(1-f1)
			f1*f1*f1*f1	f1*(1-f1)*f2*f1*f1
		Equipment		f1*f1*(1-f1)*(1-f2)*(1-f3)
		Always Fails		f1*f1*(1-f1)*(1-f2)*f3
				f1*f1*(1-f1)*f1*(1-f1)
				f1*f1*(1-f1)*f1*f1
				f1*f1*f1*(1-f1)*(1-f2)
				f1*f1*f1*(1-f1)*f1
				f1*f1*f1*f1*(1-f1)
				f1*f1*f1*f1*f1

Econometric Modeling of National Homeowner Demand

In this section we explain the econometric model in more detail. The model's first step estimates the probability that a household made a particular energy expenditure with a probit regression. In the second step, an ordinary least squares (OLS) regression estimates the expected cost of those who actually performed a project. In more technical language, let 'D' represent a binary variable that indicates whether a project has been performed in the last two years. Similarly, let 'C' indicate the project's cost. In addition, let the vector **X** represent the set of variables that will help predict the probability a project gets performed or helps predict the project costs.

The probit model estimates the probability that the project was performed for an individual 'i', denoted as p_i, conditional on a set of factors for that person, $\mathbf{X_i}$. Equation 3 shows this using econometric notation.

3) $p_i = P(D_i=1 \mid \mathbf{X_i}) = \Phi(\beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} + \ldots + \beta_n X_{n,i})$

where Φ indicates the cumulative standard normal distribution function. As a result of estimating a probit regression, empirical values of the β_j's are found using maximum likelihood techniques. Further discussion on the probit model can be found in most econometric textbooks. Table A - 3 indicates the results of the different probit models conducted in the first step.

Table A - 3 Probability a Homeowner Undertook an Energy Efficient Project in the Previous Two Years, US 2009

	Any Project Related to Energy	Insulation	Water Heater	Air Conditioning	Heating System	Window & Doors	Roof
Degree Day 2	-0.03031	-0.00180	0.05912	0.14379 **	-0.00324	-0.03982	-0.07271 *
Degree Day 3	-0.10464 ***	-0.12034 **	0.04095	0.23502 ***	-0.04606	-0.11554 ***	-0.11301 **
Degree Day 4	-0.26246 ***	-0.33583 ***	-0.02574	0.21916 ***	-0.26604 ***	-0.27025 ***	-0.15203 ***
Degree Day 5	-0.22285 ***	-0.17152 **	-0.00671	0.42651 ***	-0.42592 ***	-0.25781 ***	-0.12493 *
Degree Day 6	-0.19648 ***	-0.25069 ***	-0.01009	0.37677 ***	-0.43540 ***	-0.27073 ***	-0.12555 *
Square Feet (log)	-0.03155	0.08339 *	-0.02003	0.12981 ***	0.09769 **	-0.02945	0.02314
Min. Sq. Ft.	-0.38170 **	0.65699 **	-0.31587	0.81005 ***	0.62557 **	-0.28067	0.07056
Max Sq. Ft.	-0.23578	0.85442 **	-0.31494	1.17033 ***	0.69526 **	-0.32382	0.28868
Miss Sq. Ft.	-0.31173	0.61649 *	-0.20145	0.96901 ***	0.70952 **	-0.20144	0.24153
Single Family, Detached	0.18536 ***	0.20513 ***	0.10991 **	0.06962	0.13663 ***	0.16338 ***	0.10367 **
Mobile Home	0.12650 **	0.23361 **	0.11182	-0.03039	0.00272	0.17282 ***	0.06468
2-Story Building	-0.06611 ***	-0.11172 ***	-0.09311 ***	-0.01172	-0.04796	-0.05301 *	-0.08134 **
3-Story Building	-0.08888 ***	-0.12345 **	-0.07584 *	-0.03993	-0.01737	-0.11032 ***	-0.11439 ***
South	0.07808 ***	-0.07382	-0.04134	0.19692 ***	0.08683 *	-0.05628	0.19555 ***
Northeast	-0.00574	-0.12927 **	-0.00994	-0.05340	0.01163	-0.01123	0.11927 **
Midwest	0.09634 ***	-0.07314	0.01668	0.15170 ***	0.00950	0.03855	0.22216 ***
Suburban	-0.00928	0.00481	0.00291	0.00621	-0.01973	-0.05793 **	-0.02702
Rural	-0.05056 *	0.06939	-0.09445 ***	-0.05618	-0.01293	-0.09916 ***	-0.01009
Piped Gas Heating System	-0.00844	-0.00666	-0.05007	-0.06741	-0.13280 ***	0.04457	0.06825
Bottled Gas Heating System	-0.00343	-0.02075	-0.02567	-0.20701 ***	-0.14156 **	0.02246	0.08517
Fuel Oil Heating System	-0.06580	0.04531	-0.27456 ***	-0.24502 ***	-0.13163 **	0.04558	0.04884
Other, Non-electric Heating	0.07987	0.00601	0.13284 *	-0.12885	0.10660	0.05573	0.12824

- * significant at 10%, ** significant at 5%, *** significant at 1%

Table A - 3 Probability a Homeowner Undertook an Energy Efficient Project in the Previous Two Years, US 2009 (cont)

	Any Project Related to Energy		Insulation		Water Heater		Air Conditioning		Heating System		Window & Doors		Roof	
Income 0K-15K	-0.14893	***	-0.04016		-0.13853	**	-0.22283	***	-0.11731	*	-0.19532	***	0.04676	
Income 15K-25K	-0.08134	*	-0.09941		0.00277		-0.05406		-0.03772		-0.18570	***	0.01527	
Income 25K-35K	-0.14012	***	-0.05936		-0.17947	***	-0.22087	***	-0.15957	***	-0.16838	***	0.01671	
Income 35K-45K	-0.03744		0.03722		-0.05675		-0.13090	**	-0.07215		-0.06227		0.03650	
Income 45K-55K	-0.11316	***	-0.04619		-0.11180	**	-0.23931	***	-0.10590	*	-0.07020		-0.00007	
Income 55K-75K	-0.02888		0.02448		-0.02624		-0.11947	**	-0.05174		-0.06235		0.07629	
Income 75K-100K	-0.02941		0.03332		-0.05261		-0.06973		-0.07771		-0.04529		-0.02013	
income 100K-120K	-0.04633		0.00772		0.00211		-0.04135		-0.03746		-0.01948		-0.02510	
income 120K-150K	-0.02124		0.01099		0.02123		-0.12089	*	-0.03404		-0.04066		0.02053	
Home Age, 6-10	0.41003	***	-0.08762		0.39894	***	0.32041	***	0.48861	***	0.40227	***	0.37200	***
Home Age, 11-15	0.91261	***	0.16186		0.95932	***	0.75005	***	0.93922	***	0.64244	***	0.73432	***
Home Age, 16-20	1.08450	***	0.27209	**	0.93239	***	0.83336	***	1.14802	***	0.87763	***	1.01043	***
Home Age, 21-25	1.06910	***	0.28532	**	0.96452	***	0.84305	***	1.14657	***	0.89123	***	0.98222	***
Home Age, 26-30	1.07430	***	0.31784	**	0.91259	***	0.79257	***	1.17818	***	0.96980	***	0.87005	***
Home Age, 31-35	1.07307	***	0.47543	***	0.88310	***	0.72821	***	1.13075	***	0.97695	***	0.86338	***
Home Age, 35-40	1.08698	***	0.63385	***	0.91946	***	0.78322	***	1.15475	***	1.02853	***	0.82475	***
Home Age, 41-49	1.05860	***	0.54352	***	0.96863	***	0.75469	***	1.09881	***	0.94731	***	0.86390	***
Home Age, 50-59	1.00755	***	0.70428	***	0.92435	***	0.76983	***	1.11290	***	0.92819	***	0.79316	***
Home Age, 60-69	1.03368	***	0.74281	***	0.81817	***	0.71252	***	1.07318	***	1.01279	***	0.87763	***
Home Age, 70-79	1.02807	***	0.79511	***	0.98837	***	0.74323	***	1.11136	***	0.91919	***	0.83913	***
Home Age, 80-89	1.11394	***	0.86373	***	0.99446	***	0.60191	***	1.09451	***	1.01975	***	0.91654	***
Home Age, 90+	1.19956	***	0.94484	***	1.05881	***	0.67534	***	1.25698	***	1.02845	***	1.01016	***

- * significant at 10%, ** significant at 5%, *** significant at 1%

Table A - 3 Probability a Homeowner Undertook an Energy Efficient Project in the Previous Two Years, US 2009(cont)

	Any Project Related to Energy		Insulation		Water Heater		Air Conditioning		Heating System		Window & Doors		Roof	
# of Persons	0.01893	**	0.03121	**	0.01333		0.00620		-0.00617		0.02303	**	0.02476	**
Single Adult Household	-0.02844		-0.02925		-0.03410		0.04867		-0.05230		-0.02130		-0.04105	
High School or Less	-0.08519	***	-0.13567	***	-0.02868		0.00879		-0.04647		-0.07219	**	-0.07086	*
Some College	0.02211		0.01277		0.02359		0.04811		0.03115		0.00368		0.00441	
Bachelor's Degree	-0.03396		-0.03614		-0.03411		0.02959		-0.00187		-0.00194		-0.04600	
Recent Mover	0.03714		0.28920	***	0.10099	**	0.05891		0.11677	**	0.16481	***	-0.00296	
Person Age	0.00394		0.00708		0.00992	**	-0.00256		-0.00027		0.00536		0.00765	*
Person Age Squared	-0.00004		-0.00013	**	-0.00009	**	0.00003		0.00000		-0.00009	**	-0.00004	
Race, nonwhite	-0.07739	***	-0.11402	**	-0.03185		-0.08137	*	-0.08169	**	-0.02680		-0.06590	*
Female	-0.04299	**	-0.00898		-0.02427		0.00184		-0.03789		-0.04981	**	-0.00887	
Avg Monthly Electric Bill (log)	0.00074	***	0.00027		0.00059	***	0.00110	***	0.00069	***	0.00046	***	-0.00001	
Max Monthly Elec., Dummy	0.16985	*	0.28787	**	0.24835	**	0.40504	***	0.23299	*	0.15690		-0.19427	
No Monthly Elec., Dummy	-0.21057		-0.50560		0.07191		0.04394		-0.16375		-0.19271		-0.33790	**
Avg Monthly Gas Bill (log)	0.00062	***	0.00063	**	0.00038		0.00031		0.00041		0.00045	*	0.00093	***
Max Monthly Gas, Dummy	-0.11311		0.06244		-0.10123		-0.11762		-0.01818		0.03285		-0.06869	
No Monthly Gas, Dummy	0.02285		0.02458		-0.04581		-0.00643		-0.04018		0.04634		0.04848	
Constant	-1.39611	***	-2.88944	***	-2.35481	***	-3.67259	***	-3.21951	***	-1.82326	***	-2.86045	***
Pseudo R2	0.044		0.070		0.032		0.054		0.045		0.045		0.034	
Unweighted Observations	30,228		30,228		30,228		30,228		30,228		30,228		30,228	
Weighted Observations	76,427,983		76,427,983		76,427,983		76,427,983		76,427,983		76,427,983		76,427,983	

- * significant at 10%, ** significant at 5%, *** significant at 1%

A discussion of the most important results of Table A - 3 is left to the main body of the text. However, it is important to note that because the AHS reports the total number of dollars spent on select projects over the last two years, we assumed that the chances of those expenditures occurring in any one year was equivalent. Therefore, we divided any predicted probabilities in half.

In the second step, we use ordinary least squares (OLS) regression to model the cost of performing a project, conditional on it being undertaken. We assumed that the following relationship exists between a project's cost and the covariates:

4) $E[\, C_i \mid \mathbf{X_i} , D_i{=}1 \,] = \alpha_0 + \alpha_1 X_{1,i} + \alpha_2 X_{2,i} + \ldots + \alpha_m X_{m,i} + u_i$

where E[·] represents the expectation function, the α's are coefficients to be estimated, and the u_i term represents unobserved and random errors. OLS chooses the coefficients in such a way to minimize the sum of squared u_i terms. Any introductory econometric textbook will provide interested readers with further information on the OLS model. Table A - 4 on the next page indicates the results. A discussion of the important and significant relationships can be found in the main text.

It is important to note that the variables chosen for the econometric model are important because of the relationships that we expect should exist, but also because they include variables that were collected in our household survey. Because a predictive model is only useful if it can be used to make predictions, some variables were omitted even though they may be theoretically important.

Table A - 4 Homeowner Expenditures for Undertaking an Energy Efficient Project in the Previous Two Years, US 2009

	Total		Insulation		Water Heater		Air Conditioning		Heating System		Window & Doors		Roof	
Degree Day 2	-273.95		-143.93		-59.01		281.21		-203.69		97.42		-497.18	*
Degree Day 3	-183.97		-154.46		-33.88		368.72		-80.57		261.87		-745.68	**
Degree Day 4	-234.02		210.97		-21.47		435.68		-456.75		275.46		-369.80	
Degree Day 5	510.77		765.97	**	21.00		379.15		-483.34		19.54		1814.22	***
Degree Day 6	-520.49		87.90		16.16		294.37		-669.57	*	-312.98		-225.58	
Square Feet (log)	1536.29	***	149.93		-0.04		1142.22	***	509.64	***	464.04	*	1877.69	***
Sq. Ft. l.t. 800	10458.85	***	1018.90		-53.82		7467.47	***	3082.06	**	2908.23		12671.35	***
Sq. Ft. g.t. 7500	11644.42	***	1282.61		-69.34		7868.04	***	3578.92	**	2566.55		15227.47	***
Sq. Ft. Missing	11827.19	***	1295.74		-32.94		8777.46	***	3963.84	***	3144.13		13800.75	***
Single Family, Detached	197.70		75.43		-56.74		519.35	*	-163.11		62.49		121.11	
Mobile Home	-572.87	*	-216.54		-98.13		-496.66		-613.91		-694.73	*	-769.67	
2-Story Building	-150.37		-125.58		49.27		-224.27		211.17		112.09		131.32	
3-Story Building	-273.36		75.65		128.50	**	216.26		439.31	**	35.98		29.90	
South	-219.21		39.42		-223.37	***	-1069.91	***	-89.07		-581.58	*	-622.09	
Northeast	-655.28	**	180.07		-98.54		-481.05		-281.11		-1132.74	***	-1212.84	**
Midwest	-387.52	*	135.66		-248.34	***	-1424.11	***	-464.18	**	-483.93	*	-728.68	*
Suburban	-159.62		-142.21		49.66		-276.71		-121.75		-189.27		170.82	
Rural	-154.43		-184.05		-19.16		136.95		57.65		-544.22	**	17.68	
Piped Gas Heating System	119.60		91.89		65.95		-281.74		-206.67		219.23		254.68	
Bottled Gas Heating System	-135.22		356.28		104.98	*	-159.21		-363.59		98.77		85.16	
Fuel Oil Heating System	315.50		314.46		83.53		556.98		361.26		344.80		538.31	
Other, Non-electric Heating	289.37		-19.68		41.65		-1037.96		770.78	*	-15.63		68.25	

- * significant at 10%, ** significant at 5%, *** significant at 1%

Table A - 3 Probability a Homeowner Undertook an Energy Efficient Project in the Previous Two Years, US 2009(cont)

	Total		Insulation		Water Heater		Air Conditioning		Heating System		Window & Doors		Roof	
Income 0K-15K	-1716.65	***	-200.33		-142.27	*	-929.55	*	-183.55		-1557.23	***	-2108.04	***
Income 15K-25K	-2377.58	***	-836.07	**	-223.04	***	-1427.88	***	-593.37	*	-1845.42	***	-2793.54	***
Income 25K-35K	-2064.69	***	-765.40	***	-128.86		-1359.87	***	-178.00		-1556.02	***	-2268.87	***
Income 35K-45K	-2168.32	***	-585.92	*	-248.89	***	-1347.53	***	-652.15	**	-1853.13	***	-2017.56	***
Income 45K-55K	-1806.53	***	-711.39	**	-106.16		-1177.80	***	-21.57		-1466.99	***	-1995.94	***
Income 55K-75K	-1588.01	***	-535.84	*	-101.03		-650.35	*	-203.98		-1668.35	***	-2053.21	***
Income 75K-100K	-1796.84	***	-620.90	**	-165.24	**	-693.41	*	-344.30		-1329.97	***	-2388.32	***
income 100K-120K	-1207.76	***	-614.80	**	-139.78	*	-129.03		-387.62		-971.43	**	-2322.34	***
income 120K-150K	-1061.54	***	-891.10	***	-123.50		-497.66		-181.01		-720.68		-1273.90	*
Home Age, 6-10	403.79		-87.13		-26.98		27.91		-534.06		785.08		554.12	
Home Age, 11-15	1372.75	***	-227.98		-10.74		697.99		126.68		796.96	*	2339.48	**
Home Age, 16-20	2432.83	***	202.14		7.44		1209.21	**	-75.65		1165.16	**	2359.31	*
Home Age, 21-25	2645.96	***	-40.12		-110.60		1033.74	**	311.51		1823.31	***	2064.63	*
Home Age, 26-30	2459.64	***	153.02		-108.55		1155.79	**	-20.79		1923.89	***	2388.79	**
Home Age, 31-35	2587.79	***	369.20		-33.76		1086.51	**	297.28		2428.56	***	2001.93	*
Home Age, 35-40	2423.57	***	56.54		-84.27		1189.35	**	202.36		1961.25	***	2116.94	*
Home Age, 41-49	2421.24	***	247.47		-140.08		857.56	*	66.80		2020.95	***	2014.02	*
Home Age, 50-59	2583.49	***	205.83		35.95		1238.59	**	226.57		1734.92	***	2136.85	*
Home Age, 60-69	2661.63	***	217.49		-92.77		869.31		155.70		2112.46	***	1733.42	
Home Age, 70-79	2602.33	***	183.51		-196.54	*	2112.53	***	-177.73		1789.18	***	1529.50	
Home Age, 80-89	2768.60	***	131.29		-73.64		1398.73	*	385.41		1468.72	***	2978.33	**
Home Age, 90+	3111.76	***	190.23		-156.44		2886.74	***	295.21		2099.27	***	2157.81	*

- * significant at 10%, ** significant at 5%, *** significant at 1%

Table A - 4 Homeowner Expenditures for Undertaking an Energy Efficient Project in the Previous Two Years, US 2009 (cont.)

	Total		Insulation		Water Heater		Air Conditioning		Heating System		Window & Doors		Roof	
# of Persons	-99.00	*	-108.34	***	0.60		-136.07	*	-93.11	*	-102.16		-99.83	
Single Adult Household	-349.86	**	-325.07	**	12.27		5.75		-235.49		-385.60	*	-164.18	
High School or Less	-509.20	**	-30.51		-144.61	**	-701.93	**	-512.55	**	-210.80		-699.10	*
Some College	-390.83		3.80		-125.31	**	-318.24		-315.47		-353.76		-650.93	
Bachelor's Degree	-211.90		54.06		-83.62		-532.32	*	-283.77		-362.85		208.06	
Moved Within 2 years	953.52	***	145.65		44.89		906.04	***	219.62		172.59		143.00	
Person Age	10.11		36.75	**	-2.98		57.79	**	-7.19		16.14		-34.86	
Person Age Squared	-0.06		-0.37	**	0.02		-0.41		0.15		-0.15		0.32	
Race, nonwhite	-1008.48	***	-69.21		-54.20		-657.01	***	-649.66	***	-706.08	***	-955.32	***
Female	-64.47		-61.69		58.83	**	-229.32		118.07		-94.34		-244.95	
Monthly Electric Bill	3.77	***	1.15		0.09		0.32		2.13	*	4.57	***	4.01	**
Electric Bill g.t. 538	-642.40		169.68		139.56		-1092.26	*	-639.88		-26.17		-1250.35	
No Monthly Elec, Dummy	1002.86		103.44		170.92		3802.47		667.68		-591.90		88.06	
Monthly Gas Bill	5.94	***	2.44	*	0.96	**	3.39		2.59	*	3.66	*	4.71	**
Monthly Gas Bill g.t. 440	712.62		72.23		329.34		-142.66		-293.72		893.29		297.20	
No Monthly Gas, Dummy	496.18	**	45.14		41.20		467.02		172.93		463.37	*	400.00	
Government Assistance	1740.96	***	379.73		117.27		-12.33		331.09		183.33		880.82	
Project DIY	-2841.89	***	-971.32	***	-328.19	***	-1124.00	***	-833.31	***	-2141.14	***	-2575.30	***
Constant	-7626.46	***	11.15		1188.37	***	-5904.85	***	-85.58		-596.25		-7175.28	**
R2	0.124		0.138		0.143		0.210		0.118		0.141		0.175	
Adjusted R2	0.118		0.099		0.122		0.176		0.086		0.126		0.156	
Unweighted Observations	9,265		1,410		2,653		1,516		1,774		3,576		2,719	
Weighted Observations	23,399,588		3,667,266		6,638,654		3,981,284		4,478,834		8,933,408		6,788,390	

- * significant at 10%, ** significant at 5%, *** significant at 1%

For any individual homeowner's set of characteristics, $\mathbf{X_i}$, Table A - 3 enables us to predict the probability that the homeowner would have performed a home remodeling project related to energy efficiency within the last two years, and Table A - 4 allows us to predict the total cost of that project. To derive the expected value of that cost, one need only multiply the two predictions of the two models together. This is because

5) $E[C_i \mid \mathbf{X_i}] = E[C_i \mid \mathbf{X_i}, D_i=1] \times P(D_i=1 \mid \mathbf{X_i})$

In order to use equation 3 to create a synthetic estimate for Delaware, each individual observation created a particular $\mathbf{X_i}$ vector. Unfortunately, the survey had a relatively large number of refusals and 'don't knows' for certain key variables. Specifically, Delaware homeowners were not very forthcoming with their household's income, and they were often unable to answer information regarding the area of their home (sq. ft.). Therefore, two separate imputation methods were used (ordered logistic regression for income and linear regression for area) to generate ten alternative imputations for each missing value.[17] Ten different predicted expenditures were tabulated in each county, and the average was taken . Despite these imputations, it did not make much of a difference at the county-level which one was used.[18] Tables in the main body of the text report averages of these ten imputations.

[17] The county, number of stories in the house, age group of the house, type of housing structure, employment status, marital status, educational attainment, opinions about purchasing appliances before they break, opinions on hybrid vehicles, and opinions on energy bill worries were used to impute missing income groups via the ordinal logistic regression. The structure of the home, number of floors, age of the home, whether the unit had a basement or attic, homeowner employment status, and the previously imputed income groups were used to impute the home's expected area.

[18] We also estimated the expected expenditure for the average home in each county and scaled those expenditures by the number of homeowners in each county. Technically, this shortcut is not correct, because the expenditure of the average home does not equal the average expenditure for each home due to the nonlinearity of the normal function. Despite the technical detail, we found nearly identical county-wide probabilities, conditional costs, and total expenditures with the more appropriate approach discussed in the text. This is important, because county wide averages are less sensitive to missing data, especially given the sample sizes collected in our survey. The fact that the two approaches yielded such similar results implies that any error created through the imputation techniques is negligible.

In using the model to make predictions, we had to make two additional assumptions about projects in Delaware. First, we assumed that no Delawareans received any government aid in rebates or in subsidized low interest financing, even though the model explicitly allows for that possibility. In general, the model predicts that costs are nearly $1,741 larger when government aid is accepted, though that varies by project. As explained in the text, many different factors could explain *why* costs are larger when government aid is considered, but the point of the predictive model is simply to say *that they are larger*, and by a certain amount.

Secondly, we assumed that all homeowners would be as likely to conduct a remodeling project themselves as would the national average. Although we asked for their opinion regarding hypothetical scenarios, we felt that the historical actions taken by homeowners would probably be a better predictor than a hypothetical question. See Table 7 - 9 for the numbers behind the ratios used to calculate the proportion of homeowners performing DIY projects.